Safety and Security of Radioactive Sources: Maintaining Continuous Global Control of Sources throughout Their Life Cycle

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SAFETY AND SECURITY OF RADIOACTIVE SOURCES: MAINTAINING CONTINUOUS GLOBAL CONTROL OF SOURCES THROUGHOUT THEIR LIFE CYCLE

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FOREWORD

Radioactive sources are extensively used for beneficial purposes around the world in medical, industrial, agricultural and research applications. However, their safety and security remain a matter of concern. Loss of control, sometimes as a result of inadequate regulatory oversight, has led to ‘orphan’ sources. In some cases, such sources have resulted in serious injuries and even death. In recent years, additional concerns have emerged of the possibility that sources might be used for malevolent purposes: for example, dispersal of radioactive material in an urban environment could cause substantial social disruption. These concerns reinforce the importance of ensuring that proper control of radioactive sources is established and maintained throughout the world.

A conference held in Dijon, France, in 1998 discussed, for the first time, the need for a coordinated international approach to the safety and security of radioactive sources. A further conference held in Buenos Aires in December 2000 focused on the responsibilities of senior regulators for dealing with the matter. A large international conference, convened in Vienna, Austria, in March 2003 discussed the specific issue of the security of radioactive sources following the events of 11 September 2001.

In September 2003, the IAEA Board of Governors and the IAEA General Conference approved a revised version of the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct). Many States have since written to the Director General of the IAEA to express their desire to work towards implementing the requirements of this Code. The Group of Eight, in its Statement made at the Evian Summit in June 2003, recognized “the essential role of the International Atomic Energy Agency in combating radiological terrorism” and endorsed “its efforts to establish international standards that ensure the long term security and control of high-risk radioactive sources.” The Group of Eight indicated that it would encourage all States to strengthen controls over radioactive sources and observe the Code of Conduct, enhance international cooperation on locating, recovering and securing high risk radioactive sources, and support and advance IAEA programmes to improve the security of radioactive sources.

In June 2005, an international conference held in Bordeaux, France, provided a forum to exchange information and experience in implementing the Code of Conduct. It called for a follow-up conference three years later and for the development of a formalized process to facilitate periodic exchange of information and experience on the implementation of the Code of Conduct. A formalized Process for the Sharing of Information as to States’ Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and its associated Guidance on the Import and Export of Radioactive Sources was established in 2006, and two international open ended meetings of legal and technical experts were organized in 2007 and 2010. Several regional meetings were also organized within the framework of this process.

The International Conference on the Safety and Security of Radioactive Sources: Maintaining Continuous Global Control of Sources throughout Their Life Cycle took place in Abu Dhabi, United Arab Emirates, from 27 to 31 October 2013. It was organized by the IAEA, in cooperation with the International Criminal Police Organization, the International Commission on Radiological Protection, the International Source Suppliers and Producers Association and the World Institute for Nuclear Safety and was hosted by the Government of the United Arab Emirates. It was attended by approximately 320 participants from 87 IAEA Member States, 1 non-Member State and 6 international organizations. The conference consisted of nine plenary and two poster sessions.

The IAEA gratefully acknowledges the support and generous hospitality extended to the conference participants by the Government of the United Arab Emirates.

EDITORIAL NOTE

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SUMMARY

SUMMARY

This Conference, held in Abu Dhabi from 27 to 31 October 2013, was hosted by the Government of the United Arab Emirates through the Federal Authority for Nuclear Regulation and in cooperation with the International Criminal Police Organization, the International Commission on Radiological Protection, the International Source Suppliers and Producers Association and the World Institute for Nuclear Safety. Its purpose was to review current success and challenges in ensuring the safety and security of radioactive sources and to identify means to maintain the highest level of safety and security throughout their life cycle, from manufacture to disposal.

The timing of the Conference coincided with the tenth anniversary of the endorsement of the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) by the IAEA General Conference. To celebrate this anniversary, the first session of the Conference provided a review of the history of events which led to the development of the Code of Conduct, while the second session discussed the current status of its implementation.

Opening addresses were given by the President of the Conference and Resident Representative of the United Arab Emirates to the United Nations and the International Organizations in Vienna, by the Deputy Director General and Head of the Department of Nuclear Safety and Security of the IAEA, and representatives of the cooperating organizations.

In Session 1, two keynote addresses were given on the progress made, remaining and new challenges in the safety and security of radioactive sources.

Session 2 was devoted to the history of the Code of Conduct and to the review States' experiences in implementing the provisions of the Code of Conduct and the supplementary Guidance on the Import and Export of Radioactive Sources.

In Session 3, sustainable approaches to strengthen the safety and security of radioactive sources in the light of successful initiatives were presented.

Session 4 included presentations which discussed ways of better controlling the movement of radioactive sources throughout the world, including import and export controls and the return and repatriation of disused sources.

Session 5 addressed global industry practices and trends with regards to the design, use, recycling and disposal of radioactive sources, the development of new and alternative technologies, and associated safety and security challenges.

Session 6 discussed the long term safe and secure management of, and funding for, disused sources, including legacy sources.

Section 7 was dedicated to management of emergencies and safety and security relevant events involving radioactive sources.

Session 8 addressed important aspects of the integration of safety and security for the effective control and protection of radioactive sources in different facilities and activities.

Finally, Session 9 introduced strategies and use of new information technologies for communicating with the public on issues related to the safety and security of radioactive sources.

The Conference also included two poster sessions and one workshop on IAEA activities related to the safety and security of radioactive sources.

All speakers were invited by the Programme Committee. The presentations were followed by open discussions with broad participation from the floor. The Conference generated an exchange of information on key issues related to the safety and security of radioactive sources and the implementation of the Code of Conduct. It highlighted the main achievements since the approval of the Code of Conduct in 2003 and noted that a number of important challenges remain to be addressed. The Conference resulted in a number of recommendations, addressing mainly the legal status of the Code of Conduct, the long term management of disused sources, the interrelationship between safety and security of radioactive sources, and the implementation of the Code of Conduct information exchange process. The most important conclusions, as well as recommendations, were presented by the President of the Conference at the Closing Session and are included in the findings of the President of the Conference.

These Proceedings contain the opening addresses, the invited and contributed papers presented during the sessions, and summaries of the discussions. The findings of the President of the Conference and the IAEA closing remarks are also included. The attached CD-ROM contains the presentations of most of the papers presented orally, as well as the complete text of the printed volume. The CD-ROM also contains the national reports on implementation of the Code of Conduct submitted to the Conference by States, as per the formalized process established in 2006.

OPENING SESSION

OPENING ADDRESS

H. Alkaabi
President

Your Excellencies, Deputy Director General of the IAEA Dr Flory, distinguished guests, ladies and gentlemen.

On behalf of the UAE Government and the Board of Management of the Federal Authority for Nuclear Regulation, I welcome you to the Conference on the Safety and Security of Radioactive Sources and to Abu Dhabi, the capital of the United Arab Emirates.

The UAE Government, through the Federal Authority for Nuclear Regulation, is pleased to host this Conference. The FANR was created in 2009 as a part of the United Arab Emirate's commitment to assuring the highest standards of safety and security in the development of its nuclear programme. This commitment to highest international standards in safety and security also extends to regulation and oversight of the applications of radioactive sources, which is a task given to FANR under UAE Nuclear Law.

I am especially honoured to be the President of this Conference. The last time such a comprehensive international conference on the safety and security of radioactive sources was convened was in 2005 in Bordeaux. So it is certainly timely to meet again and to review the progress and the further challenges that lie ahead in this area. This is not to say that the subject has been neglected in the interim. Both the Nuclear Security Summits held in Washington in 2010 and in Seoul in 2012 discussed the need for States to secure radioactive sources. The more recent Ministerial Declaration adopted at the International Conference on Nuclear Security, held in Vienna in July 2013, encouraged States to maintain effective security of radioactive sources throughout their life cycle.

Discussions concerning radioactive sources at that conference also resulted in some conclusions and recommendations that will, no doubt, be further examined at this meeting. The IAEA has continued to promote and support the safety of radioactive sources through its ongoing development of safety standards and their promulgation through technical support activities.

In relation to the Code of Conduct on the Safety and Security of Radioactive Sources and its associated Guidance on the Import and Export of Radioactive Sources, which is now a decade old, we will hear from some of the originators of the Code on its past, present and possible future development. Also, hearing from countries about their successes and challenges in implementing the Code and Guidance should prove very valuable. Ways in which implementation of the Code has been supported by regional initiatives will be a topic of special interest.

The United Arab Emirates has recently made officially its political commitment to follow the guidance in the Code of Conduct and the Guidance. Nonetheless, the United Arab Emirates has, as a matter of fact, followed the guidance of the Code for some time. This is demonstrated through the description of our implementation of the Code described in our national report submitted to this Conference.

Whenever the topic of safety and security of radioactive sources is discussed, the issue of the long term management of and funding for disused sources arises. The absence of clear routes for the safe and secure handling of disused sources, including legacy sources, is a vulnerability of the existing international system. The long title of this Conference — maintaining continuous global control of sources throughout their life cycle — reminds us that the life cycle of control needs to include the end-of-useful-life stage.

Here in the United Arab Emirates, we believe that we have made progress in securing the radioactive sources used in our industries. You will hear about FANR's regulations both for the safety and security of radioactive sources. More importantly, you will hear about the practical arrangements we are implementing, working with licensees, to see that effective security plans and arrangements are put in place: both for sources at company headquarters and in the field, and also in transport.

The FANR is completing the establishment of a national register of sources consistent with the guidance in the Code. We look forward to hearing of the experiences of others in establishing national registers and using them effectively.

The fact that the United Arab Emirates has only built its industrial capacities in relatively recent times means that we are not faced with many significant legacy sources, such as large radium sources. But, like every other country, we are in the United Arab Emirates putting much effort in addressing the challenges related to dealing with disused and orphan sources. The FANR has been given the mandate to develop a national orphan source strategy, which necessarily must also encompass disused sources. We will be looking towards some of the discussion in this Conference to assist us in finalizing that strategy.

As President of the Conference, I look forward to hearing the discussion on these topics and to taking on the task of presenting President's findings for the Conference. I am sure that, in addition to reviewing the past work, we will want to point to directions for the future. The challenge of sustaining safety and security in the longer term, in countries both developed and developing, will also be an important matter to address.

Finally, I look forward to hosting delegates at the Conference dinner on Wednesday, when discussions can be more informal. I also hope that many of you will have some extra time to take in the sights of Abu Dhabi and the United Arab Emirates and experience the hospitality and culture of this country.

OPENING ADDRESS

D. Flory
Deputy Director General,
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Vienna

On behalf of the Director General of the IAEA, it is my great pleasure to be here today to open and to welcome you to the International Conference on the Safety and Security of Radioactive Sources: Maintaining Continuous Global Control of Sources throughout Their Life Cycle.

Today, we are gathered just ten years after the Code of Conduct on the Safety and Security of Radioactive Sources was approved by the IAEA Board of Governors and endorsed by the General Conference. We will have a dedicated session this afternoon to celebrate this anniversary, and you will address specific topics of the Code throughout the Conference, but I would like to emphasize a few items related to this unique international instrument, from an IAEA perspective, and start with important achievements related to the Code.

The first achievement ten years ago was the publication of an instrument addressing at the same time safety and security. The second achievement, actually a strong challenge ten years ago, is that as of today 119 States have, through their political support, recognized the value of this instrument and the necessity for safety and security applied to radioactive sources.

The political support has increased with time. The Code is being referenced in many safety and security forums, and our Director General continues to receive letters of support to the Code. These are in response to the permanent call from the IAEA General Conference and other international safety or security conference resolutions, as well as from the Nuclear Security Summits.

The third, impressive achievement is the significant progress that has been made throughout the world in strengthening the safety and security of radioactive sources. It is very important to recognize what has been achieved so far, and this Conference will serve to share and disseminate the work done over the last decade to implement the provisions and guidance of the Code of Conduct.

However, we also need to recognize that the Code is still far from being universally implemented. We need to identify remaining challenges, look ahead and agree on solutions and actions to further strengthen the safety and security of radioactive sources.

I would like to cite an observation from the International Conference on Nuclear Security: Enhancing Global Efforts, held in Vienna from 1 to 5 July 2013:

> "It is now time to move from global political support and recognition to full implementation at all stages of the life of radioactive sources."

The formalized process for States to report their progress in implementing the principles in the Code, established in 2006 upon the recommendation of the Bordeaux International Conference on the Safety and Security of Radioactive Sources, held in 2005, certainly provides one good mechanism to monitor ongoing progress and to identify and address weaknesses.

At this point, I would like to remind you that this Conference provides the opportunity, in a slightly different format than usual, to implement that formalized process of exchange of information. I want to thank the 67 Member States that have prepared, according to this process, a national report on their implementation of the Code.

I would also invite you all to take full advantage of the opportunity that this week provides, to go deeper into that information and to share your experiences in order to benefit from each other's successes and to continue paving the way for a harmonized global framework for the safety and security of radioactive sources.

I also challenge you to review and discuss this formalized process. Does it work for your State? Can it be improved? How can it be more efficient and more effective?

Returning to the core topic of the Conference, today we build upon a series of similar conferences held in Dijon (1998), Buenos Aires (2000), Vienna (2003) and Bordeaux (2005). As the title of the Conference suggests, we are here to discuss the safety and security of radioactive sources, and more specifically how to maintain control of these sources where it is already in place, and of course, how to establish it where it does not exist, yet.

As during the previous conferences, the IAEA remains fully committed to helping States to fulfil the provisions of the Code by providing all possible assistance and cooperation. I will not list in detail what the IAEA can offer but I would like to briefly explain recent changes in the way we contribute to the improvement of the safety and security of sources.

Nuclear security has gone through a significant maturation process since the Code was published. This is demonstrated through the establishment and publication of the Nuclear Security Series; this is demonstrated through the creation of the Nuclear Security Guidance Committee, similar in operation to the existing safety committees (RASSC, WASCC, TRANSC and NUSSC); this was demonstrated in July through the astounding success of the International Conference on Nuclear Security.

In addition to the publications on nuclear security which provide guidance covering broad topics, we now have in our security library three publications dedicated to the security of radioactive sources. These will be complemented in the near future by further publications currently being developed.

The IAEA has established a Working Group on Radioactive Sources Security, which held its first two meetings in November 2012 and May 2013. The next meeting is planned for 2014. This group explores the security concerns specific to high activity radioactive sources and seeks to improve the coordination of efforts to provide assistance related to those concerns.

Nuclear safety has a long history, and there have been fewer drastic changes but the IAEA continues to publish and update its safety publications. We also develop and enhance our tools and services to improve support for our Member States. In this respect, tomorrow morning you will have the opportunity to attend a special workshop that we organize to provide more information on our various actions and initiatives. And indeed, the IAEA booth in the exhibition hall is the place where you can find additional printed information. Members of the Department of Nuclear Safety and Security are present this week, and they will be happy to provide any additional information you need or to answer any questions you may have.

Together with the increased emphasis on security, there is also an ongoing debate on interfaces, integration, coordination or synergies between safety and security. While it may seem intuitive that safety and security should be compatible, there remains considerable room for further clarification.

The bare reality is that safety and security requirements and measures, if brutally applied, may create conflicts. Working on interfaces, we see our role as necessary for identifying those possible conflicts, for finding suitable solutions, and even better, for identifying synergies that would provide for joint optimization of safety and security measures. The IAEA is committed to finding ways to ensure that both of these concepts are fully addressed and neither is compromised.

At a time of global financial constraints, we all need to strive for greater efficiency and effectiveness, but this is especially true in the case of radioactive sources which are used throughout the world, especially in many States with scarce resources.

Regardless of whether we represent safety or security or whether we view the safety and security of radioactive sources as integrated or as complementary, we should all work together to optimize our national regulatory frameworks, requirements and operational conditions to achieve one common goal: protecting people, society and the environment from the harmful effects of ionizing radiation that may occur through the inadvertent or malicious use of radioactive sources. This means that States should not focus their efforts on establishing a safety regime or a security framework. Instead, efforts should be balanced to implement both safety and security in a complementary manner.

Another example of the critical interplay between safety and security involves the management for radioactive sources at the end of their useful lives. Sources can be managed safely through conditioning and proper storage, but they may still be vulnerable to theft; they can also be managed securely following physical protection principles, but that could leave them vulnerable to leaking or contamination and unnecessary exposure of people. Failure to address both safety and security equally poses a significant risk. For this reason, States are encouraged to develop and implement comprehensive national strategies for the safe and secure management of all disused radioactive sources.

I have talked a little about the history of the Code, which will be discussed in more detail shortly. I have mentioned the efforts of the IAEA to support States' efforts to implement the safety and security principles of the Code of Conduct through the development of relevant guidance, provision of training, and fostering of regional cooperation and approaches. I would also like to note that several recent international events such as the International Conference on Effective Nuclear Regulatory Systems and the International Nuclear Security Conference have emphasized the wide acceptance of the Code of Conduct as the primary international instrument defining the principles for the safety and security of sources. It has also been recognized that a State political commitment to the provisions contained in the Code of Conduct does not end States' responsibilities.

Today, this week, even more important for the IAEA, is listening to your expectations.

We know that there are many challenges related to the implementation of safety and security. These will be described in the Regional Summaries of the National Reports, as well as in several contributed papers. But there is a need to discuss these problems and to identify solutions. This requires you to present solutions developed in your countries, and you to propose ideas for discussion.

In order to keep States engaged and committed to meeting the provisions of the Code, a strategy for motivation, a strategy for knowledge and resources sustainability is necessary. This will help ensure that the safety and security of radioactive sources is sustained over the long term.

As representing your States — regardless whether you are a regulator, a technical advisor, a licensing officer, a customs and border official, a first responder or a member of the ministry of foreign affairs — each of you plays a role in ensuring the safety and security of radioactive sources in your country. By actively participating in the Conference, by sharing your national experiences and efforts, and through listening to your peers describe their successes and challenges, you and we can collectively set the tone for continued improvement for the safety and security of radioactive sources. We can make radioactive sources safer and more secure than they are today, starting from next week.

I want now to thank the Federal Authority for Nuclear Regulation, and through it, the Government of the United Arab Emirates for hosting the Conference. It is very positive and inspiring to all that a country and a regulatory body so much engaged in establishing its nuclear programme still gave significant importance to the safety and security of radioactive sources.

The IAEA is also very grateful to the cooperating organizations that will contribute to the debate and to the success of this Conference.

Finally, it is a pleasure to acknowledge the participation of 100 States, 13 international organizations and 420 delegates registered in this Conference. Considering the limited resources of the IAEA to organize international conferences, I want to express my gratitude to the Governments of Belgium, Denmark, India, the Republic of Korea and the United States of America for their very generous extrabudgetary donations. Thanks to their support, this Conference has been made possible, including travelling to Abu Dhabi for many participants.

Thank you for your attention and I wish you a successful Conference.

PROGRESS MADE, REMAINING AND NEW CHALLENGES IN SAFETY AND SECURITY OF RADIOACTIVE SOURCES

(Session 1)

Chairperson

W. TRAVERS
United Arab Emirates

Rapporteurs

C. GEORGE
IAEA

H. MANSOUX
IAEA

RAPPORTEURS' SUMMARY

Session 1: Progress Made, Remaining and New Challenges in Safety and Security of Radioactive Sources

C. George, IAEA
H. Mansoux, IAEA

This session consisted of the keynote addresses delivered by A. Gonzalez and C. Englefield to set the scene for the week on the evolution over the last decade of safety and security of radioactive sources. A. Gonzalez introduced the history of the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct); proposed that the security of radioactive sources be considered an important but subsidiary component of the safety of radioactive sources; and proposed a call for action to include:

— Tasking a working group to consider an international convention on the safety and security of radioactive sources using the Code of Conduct as its basis;
— Developing a comprehensive set of standards for radioactive material which integrates safety standards with security guidance;
— Establishing a committee to optimize all safety and security services provided by the IAEA under its mandate.

C. Englefield reviewed the current threat of nuclear terrorism and the need for a global capability in nuclear security. The main thrust of the address was the need for a 'professionalization' of nuclear security specialists working with radioactive sources as a means to ensure sustainability. The approach taken by the United Kingdom was presented. It was noted that existing nuclear security expertise and knowledge can and should be used by those responsible for the security of radioactive sources.

Some of the discussions were directly linked to the topic of education and training, comprehensive and sustainable training programmes on safety and security of sources, building on existing competences in related fields. The proposal of professionalization of nuclear security specialist was welcome.

Most of the discussion focused on the proposal to consider an international convention on safety and security of radioactive sources. Several advantages were put forwards, such as the leverage it would represent for regulatory bodies to obtain political and financial support from their governments, so that they can adequately fulfil their mandate. Among the concerns expressed, it was clearly stated that there are no guarantee that a convention would include the same provisions as the current Code of Conduct, or that it would attract a similar number of Member States to those currently supporting the Code of Conduct. Furthermore, it was felt that the development and eventual ratification of such a convention and the implementation of its requirements would take much more time than was the case with the Code of Conduct, and might divert resources needed for further improving safety and security of sources worldwide. Participants also expressed concern about how a convention might be introduced in parallel with the existing Code of Conduct continuing to be followed. There could also be conflicts in scope and requirements which could dilute the effectiveness of existing safety and security provisions.

A point raised during the discussion was that the IAEA should consider convening a working group to assess the merits of developing a convention on the safety and security of radioactive sources and to make recommendations. This would enable an informed decision to be made with regard either to continue with the extant Code of Conduct or to seek Member State support for the development of a legally binding convention.

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ENSURING THE SAFE USE OF RADIOACTIVE SOURCES*
Progress and remaining challenges

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Abstract

The concepts of 'safety' and 'security' are examined with the purpose of reaching a common basic understanding on the meaning of ensuring the safe use of radioactive sources by maintaining their continuous global control throughout their life cycle. The origins of the international interest on the safety and security of radioactive sources are described within the frameworks established by the IAEA's statutory functions and by the growing global concerns on the menace posed by international terrorist activities. The enormous progress on the control of radioactive sources achieved until now by the international community is analysed, not only in terms of fostering information exchange but also of concrete undertakings. The possible future tackling of remaining challenges is explored. A call for action is submitted for achieving a robust international regime for the control of radioactive sources.

1. INTRODUCTION

This paper is aimed at describing the progress and remaining challenges for ensuring the safe use of radioactive sources. It has been prepared for this conference in Abu Dhabi. The paper therefore addresses two concepts which are very much misunderstood and which have caused (and continue to cause) enormous confusion: namely, the concepts of safety and security. The confusion between safety and security may obscure the main strategic aim of ensuring the safe use of radioactive sources, which is well expressed by the Abu Dhabi Conference's motto: maintaining the continuous global control of sources throughout their life cycle.

By necessity, the paper has to explore first some common basis for understanding the issues, including: defining the international starting point; describing the recurrent misunderstanding on safety and security; restating the

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* The views and recommendations expressed here are those of the author, and do not necessarily represent those of the IAEA.

IAEA's statutory functions; distinguishing security and terrorism; in sum, dealing with crucial concepts first. Then, the paper summarizes the enormous progress achieved in fostering information exchange, much less in legally binding undertakings, much more in 'morally' binding undertakings, such as codes of conduct and international standards. Finally, the paper explores the feasibility of a new future tackling the remaining challenges. The paper concludes with a call for action which hopefully will guide the international community to a desideratum: an international regime for the control of radioactive sources.

2. BASIS FOR A COMMON UNDERSTANDING

2.1. International starting points

During the early efforts to protect people against the deleterious effects of exposure to ionizing radiation, the safety and security of radioactive sources was taken as granted by most national and international recommendations and standards. The main objective was to limit the expected exposure of people and the basic concept was that unexpected (or abnormal) situations should be 'prevented'. The concept of 'prevention' was loosely used to mean keep from happening or arising, making unable to occur, but how to achieve prevention was not clear. The concept of safety level was rarely used and the idea of security was absent (or perhaps implicit).

International standards addressing safety and security of radioactive source would not see the light until 1996. At that time the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) would be issued by the IAEA they were jointly sponsored by the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Pan American Health Organization (PAHO) and the World Health Organization (WHO), and issued by the IAEA as IAEA Safety Series No. 115.[1]

The BSS were the first international regulatory instrument that included a detailed treatment of the main topics surrounding the safety of radioactive

[1] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

sources, such as management requirements, technical requirements and requirements for the verification of safety. It covered issues such as the safety assessment of sources and requirements for their safety design and operation, as well as quality assurance.

Notably, the BSS also summarily addressed the issue of the security of radioactive sources as one necessary although not sufficient safety requirement. It simply required that sources be kept secure so as to prevent theft or damage and to prevent any unauthorized person from carrying out any of the actions specified in the standards. The security requirements of the BSS were simple but not simplistic: it demanded that the control of sources not be relinquished and immediate communication of any decontrolled, lost, stolen or missing source; that a source not be transferred without conditions; and that periodic inventory of movable sources be conducted to confirm that they are in their assigned locations and are secure. Straightforward adherence to these simple requirements would have prevented many of the mismanagements that would occur in the future.

The earliest international fostering of information exchange on safety and security of radioactive sources took place one year after the BSS publication. In 1998, the safety of radiation sources, including the security of their radioactive materials, first acquired international relevance during the International Conference on the Safety of Radiation Sources and Security of Radioactive Materials (Dijon Conference) [1]. The event was organized by the IAEA in Dijon, France, from 14 to 18 September 1998 (three years before the terrorist attacks on 11 September 2001), and jointly sponsored by the European Commission, INTERPOL and the World Customs Organization. This conference (the achievements of which will be discussed later) was the starting point of the international interest in the safety and security of radioactive sources.

Following the Dijon Conference, the associated regulatory problems of safety and security of radioactive sources were recognized by competent authorities in their first encounter on the issue, the International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials (Buenos Aires Conference) [2], which was organized by the IAEA, in Buenos Aires, Argentina, from 11 to 15 December 2000 (nine months before 11 September 2001).

The BSS and the Dijon and Buenos Aires Conferences were undoubtedly the starting points towards the internationalization of the safety and security of radioactive sources. As a result of these initial efforts, on 10 September 2001, the IAEA Board of Governors approved an action plan on the safety and security of radioactive sources. Ironically, just one day after, on 11 September 2001, the terrorist attacks on the United States of America occurred creating the conditions to accelerate these initiatives.

2.2. A recurrent misunderstanding

A confusing issue that has dominated the international developments for ensuring the safe use of radioactive sources has been the uncertainty in the understanding of the English terms ‘safety’ and ‘security’. In fact, safety and security are distinguishable terms in English, but the same word is used to denote these concepts in other major languages, which obviously creates major confusion.

It should not be surprising that, in its title, this paper refers only to the ‘safe’ (rather than the ‘safe’ and ‘secure’) use of radioactive sources, despite the fact that it is being submitted to an international conference on the safety and security of radioactive sources. The reason is that an elemental purpose of the paper is to underline again an obvious fact that the author has been repeating ‘ad nauseam’ but to no avail: **the security of radioactive sources is a necessary but not sufficient condition for the safety of radioactive sources**. Namely, however important it may be, **the security of sources is subsidiary to the safety of sources**. (It must be noted that the term ‘subsidiary’ is not used derogatively but just to indicate that security is supplementary to safety.)

The above is not a trivial principle. In fact, in dealing with safety and security of **radioactive sources**, there are four feasible alternatives: either to consider them two independent entities, or to assume that they have some (but not all) areas of synergies, or to consider that safety is one element of security or, vice versa, that security is one important but inclusive element of safety.

Figure 1 simplistically illustrates the four feasible alternatives for the interaction between safety and security. Any of these alternatives could be applicable to particular situations. For instance: the safety in a bank and the security of its assets are usually mainly independent one to each other, but can interact in some situations; in military operations safety is usually subsidiary to security. But for the specific problem of radioactive sources, security needs to be a requirement in safety.

By ‘the safety of radiation sources’, we usually mean the assembly of technical and managerial features that diminish the likelihood of something going wrong with a source as a result of which people become overexposed. By ‘the security of radioactive source’, we mean the assembly of technical and managerial features that prevent any unauthorized activity with radioactive sources by ensuring that their control is not relinquished or improperly transferred. Security is required to prevent stray radioactive sources causing harm to people. This implies that the security of radioactive sources is a constitutive, important but subsidiary, component of the safety of radioactive sources.

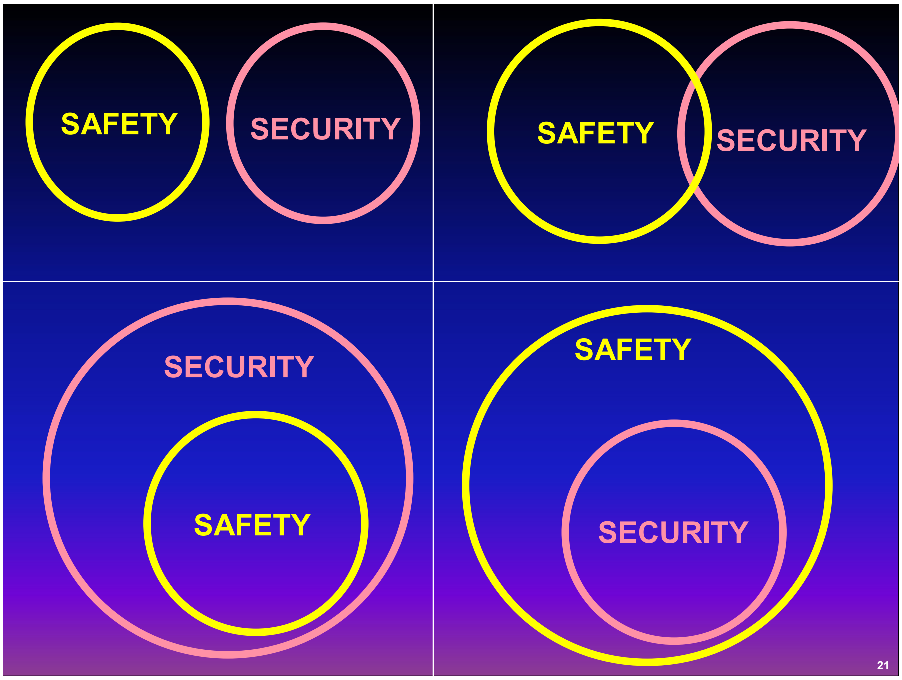

FIG. 1. The feasible interactions of safety and security.

It could therefore be concluded that the concept of ensuring the safe use of radioactive sources includes that of ensuring their secure use and that the repetitive use of the expressions ‘safety and security’, ‘safe and secure’ is simply tautological and perhaps confusing. Within the context of radiation sources, ‘safety’ means to prevent the sources causing harm to people and ‘security’ means to inhibit unauthorized and unlawful use of radioactive sources, for example by ensuring that control over radioactive materials is not relinquished or improperly acquired. It follows that the ‘security of radioactive sources’ is a necessary (but not sufficient) condition for the ‘safety of radioactive sources’. This is because of simple logic: while a secure radioactive source (namely, a source where its radioactive materials are kept secure, under proper control and physically protected) is not necessarily a safe radiation source (namely, a source unlikely to produce radiation harm), a radioactive source cannot be safe unless its radioactive materials are secure. (Usually the security requirements are limited to radioactive materials alone and not to radioactive sources (as a whole) because security issues with the apparatus which generates ionizing radiation, such as X ray and computer tomography machines and accelerators, are of less security significance.)

The misunderstanding between the concepts of safety and security is not a semantic problem. It has caused misinterpretations and misapprehensions and a vast waste of intellectual energy and precious resources.

The confusion has been aggravated by translation. Safety originated from the Latin adjective *salvus*, meaning well, unharmed, saved; security comes from the Latin adjective *securus*, which literally means without care, carefree, careless, but is used as antonymous of these concepts. But most major European languages other than English have lost or mess-up these original Latin roots. These languages do not make distinction between safety and security, having lost the *salvus* root and just kept the *securus* root to mean both, safety and security. In the Castilian language, the problem was addressed by qualifying the noun with the adjectives technological (for safety) and physical (for security), a mistaken qualification that has enhanced uncertainty [3].

Security is also required to avoid control of nuclear weapon being relinquished, a serious challenge for nuclear weapon States but not an issue for the vast majority of countries which have renounced nuclear weapons and certainly an issue that is foreign to radioactive sources. Security, finally, is required to prevent the diversion of nuclear materials from legal to illegal, even criminal, uses; but this is an issue related to the safeguards of nuclear materials not to safety in general, and particularly not to the safety of radiation sources.

The self-evident logic of security of radiation sources being an element of the safety of radiation sources was crystal clear before the drama of 11 September 2001, but it became diluted afterwards in the outburst of security activities triggered by those ill fated events. As a result, many misunderstandings occurred, technical mistakes were made, resources were wasted, and on many occasions safety was undesirably hampered. Thus, international security 'guidelines' were developed by the IAEA outside the primordial system of international safety standards, a system which was being established under the aegis of the same IAEA. The lack of coherence and consistency among the documents produced was an avoidable and unwelcome result.

2.3. The IAEA statutory functions

Within the context of the Abu Dhabi Conference, which was an IAEA gathering, it is important to recall the statutory functions of the IAEA in relation to ensuring the safe use of radioactive sources. The Statute of the International Atomic Energy Agency clearly institutes relevant safety functions for the IAEA, namely: (i) to establish standards of safety; and (ii) to provide for the application of these safety standards at the request of a State. The word 'security' is absent from the IAEA Statute, although at the time of the Statute's drafting, 'security' was a crucial term in United Nations language; an archetypical example is its use in the title of the United Nations' highest executive body, the Security Council, which had been established just before the IAEA Statute.

Does the absence of the term security in the IAEA Statute mean that those who drafted it, and the many States that immediately adhered to it, did not wish security to be part of the IAEA's remit? While unfortunately formal evidence to probe it is not available to the author, after personal discussions with experts involved in the genesis of the IAEA Statute, and following the application of straightforward principles of logic, the author concluded that the IAEA Statute presupposes that relevant security functions were from the start a constitutive part of the IAEA statutory safety functions.

Legal officers at the IAEA Secretariat have arrived at the conclusion that the IAEA security activities are statutorily based [4], but this could be misunderstood. The Statute does not explicitly authorize the IAEA to involve itself in security activities 'per se' and, while security activities by the IAEA are essential for discharging the IAEA safety functions, they cannot be statutorily justified in isolation of its safety function.

As indicated before, the approach used by the IAEA before 11 September was, unsurprisingly, to establish security requirements as an integral part of its safety requirements. Security was not tackled in isolation to safety.

The terrible events of 11 September did provide justification to an expansion of security requirements within the IAEA safety standards but they did not validate the de facto programmatic distortion that followed within the IAEA, with security becoming a kind of independent programme increasingly isolated from the IAEA safety remit. Thus, a so termed 'nuclear' security programme was established outside the major IAEA statutory responsibilities, which was managed by an 'office', rather than an established organic unit, and financed mainly through extrabudgetary resources.

2.4. Security and terrorism

Another unfortunate outcome from the security outbreak that followed the 11 September events was the de facto equalization of security and antiterrorism. This somehow resulted in an undesired limitation, reducing the complex strategic problem of combating terrorism into a tactical necessity of the moment.

An essential fact was simply ignored: most of the many security breaches occurred in the use of radiation sources, several of which resulted in serious public harm (including fatalities), had been the result of incompetence, ineffectiveness, ineptitude and even stupidity, rather than of maliciousness or malevolence. The detailed causes and consequences of some of these accidents have been reported internationally (see, for example, Refs [5–12]).

It was a failure to recognize that the antiterrorism tuned refinements in the security requirements were needed as a preventive measure for imaginable scenarios rather than a reaction to events that had factually occurred. This was a significant difference with other safety requirements, which responded to factual occurrences rather than hypothetical circumstances.

In fact, as the International Commission on Radiological Protection (ICRP) has recognized, secured sources can, and have, become unsecured through a variety of circumstances, not necessarily through terrorism [13]. Historically, in the most common cases, control over the source was relinquished inadvertently, and then the source was misused, without any premeditated malicious intent. In other cases, many sources have been found to be orphaned of any control and were therefore completely unsecured. A relatively large number of radiological accidents have occurred because of these unintentional breaches in source security or because an orphan source was inadvertently found.

Perhaps, a lot of energy and resources could have been saved if it had been recognized that a main relevant issue for dealing with radiological and nuclear terrorism was to guide decision makers for responding to security breaches leading to a radiological or nuclear terrorist incident, as promoted by the US National Council on Radiation Protection and Measurements [14].

It is firmly emphasized that the aim of the above clarifications on security vis-à-vis terrorism is not intended to undermine the crucial importance of the security of radioactive and nuclear materials and facilities in the fight against global terrorism in all its forms. The objective is rather to facilitate the formulation of a rational international strategy on this fundamental issue in order that the tactics for improving radioactive source security be logical, realistic and effective.

2.5. Recapitulating some crucial concepts

It seems, therefore, that within the statutory responsibilities of the IAEA, the crucial concept to be re-emphasized are:

(i) The security of sources is a necessary, although not sufficient, condition for their safety; namely, source security is an indispensable part of source safety.
(ii) The main security concept is to prevent the relinquishing of source control in order to avert their misuse.
(iii) Source security is a generic concept to be applied to the prevention of any misuse of sources and not only to the malicious or malevolent misuse.

An unambiguous international consensus on these essential concepts is a precondition for seriously assessing ‘progress and remaining challenges’ in this controversial topic.

3. PROGRESS BEING MADE

Assessing the progress being made in the safety of radiation sources, including their security, is crucial for the future of nuclear energy and its by-products, and it is a precondition for addressing the unresolved challenges. This part will review progress in fostering information exchange, legally binding undertakings, and other relatively binding undertakings, such as codes of conduct and international standards.

3.1. Fostering information exchange

Since the international starting points for a common understanding on the safety and security of radioactive sources, there has been an enormous international drive for fostering information exchange. The Dijon and Buenos Aires Conferences were more than a triggering event. They were professional forums where a deep fostering of information exchange took place.

3.1.1. The Dijon Conference

As indicated before, the Dijon Conference was the first international attempt to exchange information on the issue of source safety and security. At the conference, our priorities for action were clearly expressed:

- The application throughout the world of the international requirements for ensuring the safe use of radioactive sources (as established in the BSS) should be encouraged by the IAEA.
- Security requirements on radioactive materials should be greatly expanded.

The conference concluded underlining a number of relevant issues, as follows:

- Protection to allow for safe and secure normal operations of sources should be provided.
- Possibility of accidental exposures should be anticipated.
- Weaknesses in design and construction should be corrected.
- Safety culture in the use of sources should be promoted.

— Relinquishing control of sources should be prevented.
— Orphan sources should be found and control of them should be regained.
— Detection at borders or inside countries of movement of uncontrolled sources should be improved.
— Investigation levels at border crossings should be established.
— It should be guaranteed that regulatory authorities will have sufficient backing and human and financial resources to ensure the above.

But perhaps one of the more relevant outcomes from the Dijon Conference was the call for considering the formulation of international undertakings to ensure the safe and secure use of sources.

3.1.2. The Buenos Aires Conference

As indicated before, the Buenos Aires Conference marks the beginning of the international regulatory interest on the issue of safety and security of radioactive sources. At the conference, we submitted additional reflections on the prevailing issues, as follows:

— Some regulatory authority exists on paper but not in practice; namely, they have been set up by proper legal procedures but do not exercise their functions.
— A number of States which are suffering from this problem have adopted national legislation as a necessary and sufficient measure — which is an extremely dangerous illusion.
— The absolutely necessary condition guaranteeing the safety and security of radiation sources is a regulatory critical mass of technically well educated and competent professionals with sufficient resources and the political commitment from the government to support them.

The regulatory information exchange at the Buenos Aires Conference was vast and included the following topics:

— Education and training (the key factors);
— Identifying States with difficulties;
— Knowing the situation;
— Effective independence of the regulatory authority;
— Insuring radiation sources;
— Learning from accidents;

— Universal system of labelling;
— Radiation source registry;
— Continuity of control;
— Return of sources;
— Arrangements for handling orphan sources;
— Emergency arrangements;
— Criminal activities;
— Provision of technical assistance.

The Buenos Aires Conference also produced a ‘call for action’, which included:

— Providing for the application and implementation of the recently adopted Code of Conduct (see hereinafter);
— Making use of the recently established Categorization of Radiation Sources (see hereinafter);
— Adopting strategies for education and training;
— Establishing inventories of disused sources;
— Ensuring that disused sources are kept in storage;
— Developing national strategies for localizing orphan sources;
— Carrying out assessments of the effectiveness of radiation safety regulatory infrastructures;
— Encouraging users, manufacturers and regulators to exchange information about problems and successes.

3.1.3. The Vienna Conference

The events of 11 September triggered a new dimension on these efforts of information exchange. From 10 to 13 March 2003, the IAEA convened an excellent and comprehensive International Conference on Security of Radioactive Sources (Vienna Conference) [15]. It was held in the portentous Hofburg Palace, in Vienna, Austria, and attended by a multitudinary audience.

New dimensions in the old issue of securing radioactive sources were underlined at the Vienna Conference, such as:

— The potential aim of malevolent groups to cause widespread panic and harm among civilian populations by simple security breaches in the control of sources.
— Their perceived ability of to work with modern technologies.

- The possible suicidal approach of perpetrators, meaning that the deadliness of handling intensely radiological material could no longer be seen as an effective deterrent.
- The global characteristics of the threat.

At the conference, we underlined our own concerns (which were being repeated to no avail since the Dijon Conference), including:

- Radioactive sources are abundant and therefore easily available throughout the world.
- Many radioactive sources have been orphaned of any control.
- Some of the orphan sources, holding large radioactive inventories, were designed for 'unconventional uses' (a sophism for quasi-military uses).
- Even those radioactive sources that are well regulated are not necessarily well secured and orphan sources are usually completely unsecured.
- Badly secured radioactive sources are amenable to diversion into malevolent use and potential terror.

The Vienna Conference would eventually identify a number of concluding issues that will model the work ahead, including:

- 'Orphan' sources raise serious security concerns and international initiatives to facilitate their location, recovery and securing throughout the world should be launched.
- Effective national infrastructures for the safe and secure management of radioactive sources are essential.
- States should make a concerted effort to follow the principles contained in the Code of Conduct.
- Identification of the roles and responsibilities of governments, licensees and international organizations is vital.
- International initiatives to encourage and assist governments in their efforts to establish effective national infrastructures and to fulfil their responsibilities instigated and initiated.

After the Vienna Conference, there was a de facto international consensus in ensuring source security control (i.e. that source control should be relinquished) from 'cradle to grave', namely from manufacture to disposal, as illustrated in Fig. 2.

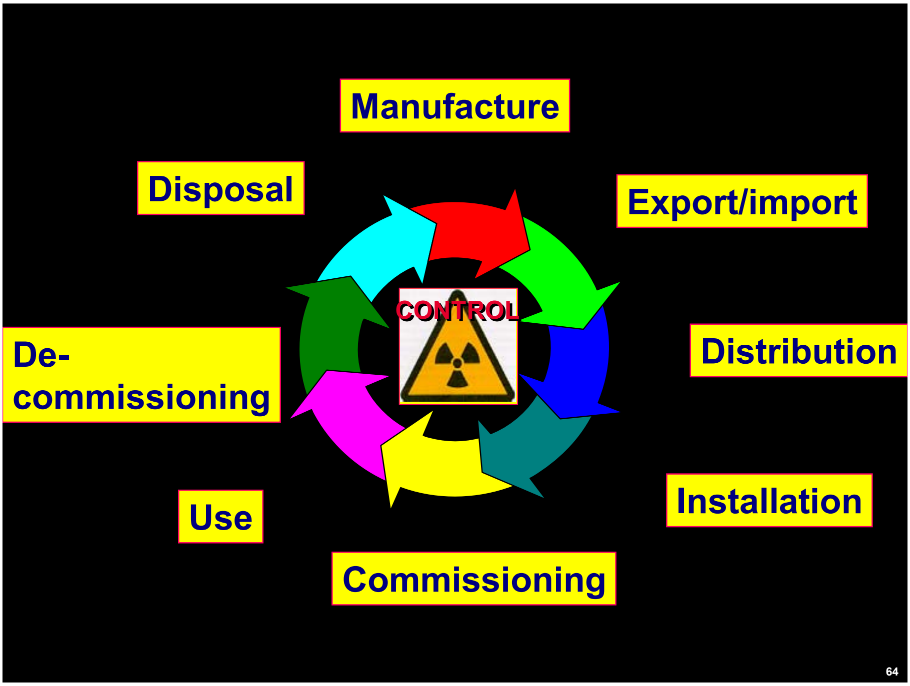

FIG. 2. Control of radioactive sources are not to be relinquished from 'cradle to grave'.

3.1.4. The Bordeaux Conference

An attempt towards a global system for the continuous control of sources throughout their life cycle was done at the International Conference on Safety and Security of Radioactive Sources, held in Bordeaux, France, from 27 June to 1 July 2005 (the Bordeaux Conference) [16].

At the Bordeaux Conference, we made again crystal clear our critique and desires, as follows:

- The IAEA assistance is being absorbed and further initiatives (with a lot of money) will be launched, but no international initiative can replace countries' own actions.
- The time is ripe for binding commitments for a harmonized, effective and sustainable international regime on the safety and security of radioactive sources.

In any case, the Bordeaux Conference's conclusions were very important and included the following:

— The Code of Conduct and the Guidance on Import/Export are very good tools for the control of radioactive sources.
— The IAEA and Member States should consider a solid mechanism for applying them.
— Strict control over the entire cycle of sources is to be exerted.
— Awareness among all those involved is to be raised.
— Illicit trafficking of sources is to be detected.
— States are expected to cooperate.

3.1.5. The Tarragona Conference

An important international event of information exchange relevant to the safety of sources has been generally unnoticed. From 23 to 27 February 2009, the International Conference on Control and Management of Radioactive Material Inadvertently Incorporated into Scrap Metal was held in Tarragona, Spain (Tarragona Conference) [17]. The event was organized by the Spanish Nuclear Safety Council in cooperation with the IAEA, and the issues discussed are essential for the safety of sources as they addressed the control and management of radioactive material inadvertently incorporated into scrap metal.

Our proposal at the Tarragona Conference was that the international community ought to develop a legally binding intergovernmental undertaking, which should:

— Resolve the current regulatory ambiguity for controlling scrap metal;
— Facilitate commercial exchange;
— Result in improved public protection by ensuring the safety of sources.

We suggested that such legally binding undertaking might take the form of a 'Codex Metalicus', similar to the existing Codex Alimentarius for edible commodities, which might indicate the amount of radioactive impurities in various metals that be unacceptable for reasons of safety and security.

It has to be noted that the participants of the Tarragona Conference were unanimous in recognizing the potential benefit that would result from establishing some form of binding international agreement between governments to unify the approach to transborder issues concerning metal scrap containing radioactive material. At present, there are no international legal instruments that cover the transborder issues associated with radioactive material found in scrap metal.

3.1.6. Results

After three lustrums of significant and valuable fostering of information exchange on the safety and security of radioactive sources, the results of the exchange has not always been applied in practice. For instance, the world is still lacking a serious international regime on these issues. In spite of the good intentions, the security approach continued to be isolated from the IAEA main remit that is the establishment of international standards on safety, which were and continue to be the main focus for a global system of control.

3.2. Legally binding undertakings

There are no legally biding undertakings on the safety and security of radioactive sources. Primary legal instruments dealing with safety under the auspices of the IAEA are: the Convention on Early Notification of a Nuclear Accident; the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; the Nuclear Safety Convention; and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The existing safety conventions could cover some safety and security obligations in relation to radioactive sources, but they were designed for different purposes; for instance, the term security does not appears in them even once in this instruments.

The instruments addressing the issue of security exclusively are the Convention on the Physical Protection of Nuclear Material (CPPNM) and the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), and two resolution of the United Nations Security Council: United Nations Security Council resolution 1373 (2001), which is aimed at preventing and suppressing the financing of terrorist acts; and the United Nations Security Council resolution 1540 (2004), which is aimed at States to adopt legislation to prevent the proliferation of nuclear, chemical and biological weapons. There are also some related primary legal instruments under the auspices of the International Maritime Organization (IMO): the Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, and the Protocol for the Suppression of Unlawful Acts Against the Safety of Fixed Platforms Located on the Continental Shelf. The IAEA is also cooperating with the United Nations Counter-Terrorism Implementation Task Force, especially on interagency coordination in the event of nuclear terrorism.

While extremely important for the global fight against terrorism, all these undertakings and activities seem to be collateral to the main objective of ensuring the safe and secure use of radiation sources.

3.2.1. Convention on the Physical Protection of Nuclear Material

The CPPNM was not originally conceived for securing radioactive sources but for a different purpose, namely avoiding the diversion of special fissionable material in transit. The IAEA's role in respect of the CPPNM is limited: parties may or may not use the IAEA to communicate to each other their national point of contact with responsibility for physical protection of nuclear material and for coordinating recovery and response operations in the event of a breach. If an incident occurs parties are required to cooperate to the maximum feasible extent in the recovery and protection of nuclear material.

3.2.2. International Convention for the Suppression of Acts of Nuclear Terrorism

The ICSANT entered into force in 2007, and again is not a legal binding undertaking for the safety or security of radiation sources but an instrument to establish a wide variety of offences in relation to nuclear terrorism. The treaty names the United Nations Secretary-General rather than the IAEA Director General as depositary and therefore it is not considered to be within the IAEA's 'family' of treaties. The IAEA does assume, however, a number of functions: if a State seizes control of any radioactive material, devices or facilities following the commission of an offence, that party needs to ensure, inter alia, that they are held in accordance with IAEA nuclear safeguards and need to "have regard" for IAEA "physical protection recommendations and health and safety standards".

3.2.3. The United Nations Security Council resolution 1540

United Nations Security Council resolution 1540, which was adopted in April 2004, is not a treaty and is not related to safety and security of radioactive sources. It is supported by a small secretariat at United Nations headquarters in New York, which is supposed to seek the assistance of relevant United Nations organizations already involved in preventing the proliferation of nuclear, chemical and biological weapons. It is also supposed to match requests for assistance in implementation with offers by other States to provide such assistance. The IAEA has recognized that the resolution is an integral part of the international legal framework for nuclear security [4].

3.3. Code of Conduct

The absence of legally binding undertakings on safety and security of radiation sources was replaced by a code of conduct. The Code of Conduct on the Safety and Security of Radioactive Sources [18] was approved by the IAEA Board of Governors on 8 September 2003. A supplementary Guidance on the Import and Export of Radioactive Sources [19] was subsequently issued in 2005.

The Code of Conduct is a peculiar instrument, which was originally termed *Code de bonne conduite* during the debates at the IAEA Board of Governors. It is neither recognized in international conventions and treaties nor by the IAEA Statute. It seems to be a systematic collection of a set of conventions governing behaviour or activity in relation to the safety and security of sources, addressing generally acceptable behaviours, directions and managing attitudes for the control of radioactive sources.

It is interesting to note that the original direction of the Dijon Conference for a legally binding undertaking evolved into a non-legally binding 'code of conduct'.

Most governments have adhered to the Code of Conduct and the related guidance and thus they have contributed enormously in addressing challenges for ensuring the safe use of radioactive sources. The Code and its Guide are therefore a much welcomed development, but a code of conduct is not a legally binding undertaking.

3.4. Standards

3.4.1. International Commission on Radiological Protection

Following an early decision of the IAEA Board of Governors [20], the IAEA safety standards are to take account of the recommendations of the ICRP. The ICRP has clearly indicated that source security is a necessary, although not sufficient, condition to ensure source safety; namely, that if a source is not secure, it is not safe, and that, conversely, sources that are secure are not necessarily safe [13].

3.4.2. International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources

Unsurprisingly, the BSS included security requirements as an integral part of the safety requirements. As requested by the Statute, the BSS had been approved by the IAEA's Board of Governors (at its 847th Meeting on 12 September 1994), and were cosponsored by other relevant organizations in the United Nations family.

3.4.3. The revised BSS

The BSS were recently revised.[2] The new BSS are ambiguous about security. They warn the reader that: “Security related publications are issued in the IAEA Nuclear Security Series”; while recognizing that: “Safety measures and security measures have in common the aim of protecting human life and health and the environment” and that “safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.”

Referring to leadership in safety matters, the new BSS require that it “has to be demonstrated at the highest levels in an organization, and safety has to be achieved and maintained by means of an effective management system”, which “has to integrate all elements of management so that requirements for protection and safety are established and applied coherently with other requirements, including those for health, human performance, quality, protection of the environment and *security*, together with economic considerations” (author’s emphasis). (It is not clear what an applicant can do to implement this obscure requirement.)

The new BSS also require that to ensure that the likelihood of an accident having harmful consequences is extremely low, measures have to be taken to prevent the occurrence of failures or abnormal conditions (including breaches of *security*) that could lead to such a loss of control.

The new BSS address (in a dedicated section) “Interfaces between safety and security” as if they were two separate entities. Notably, they declare that they “do not deal with security measures” because the “IAEA issues recommendations on nuclear security in the IAEA Nuclear Security Series”. However, it requires that governments “shall ensure that infrastructural arrangements are in place for the interfaces between safety and the security of radioactive sources.”

Unfortunately, a great confusion permeates the full new BSS, starting by the restrict definition of nuclear security, which is limited to “*malicious* acts involving *nuclear material*, other *radioactive material* or their associated *facilities*” (original emphasis).

The new BSS are a clear example of the international uncertainty and misunderstanding on the issue of security of radiation sources.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GRS Part 3 (Interim), IAEA, Vienna (2011). Since the time of writing this paper, the BSS have been further revised (see Ref. [21]). This paper refers to the 2011 version.

3.4.4. The Fundamental Safety Principles

In 2006, the IAEA established Fundamental Safety Principles [22], so termed Safety Fundamentals, which benefit from the wide joint sponsorship of the European Atomic Energy Community, the FAO, the ILO, the IMO, the OECD/NEA, the PAHO, the United Nations Environment Programme and the WHO. The Safety Fundamentals recognize that: “Safety measures and security measures have in common the aim of protecting human life and health and the environment”.

Moreover, the Safety Fundamentals indicate that [22]:

> “The safety principles concern the security of facilities and activities to the extent that they apply to measures that contribute to both safety and security, such as:
>
> — Appropriate provisions in the design and construction of nuclear installations and other facilities;
> — Controls on access to nuclear installations and other facilities to prevent the loss of, and the unauthorized removal, possession, transfer and use of, radioactive material;
> — Arrangements for mitigating the consequences of accidents and failures, which also facilitate measures for dealing with breaches in security that give rise to radiation risks;
> — Measures for the security of the management of radioactive sources and radioactive material.”

The Safety Fundamentals further recognize that [22]:

> “Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.”

Notwithstanding the above, fundamental principles for dealing with security are absent from the Safety Fundamentals.

3.4.5. Nuclear security ‘standards’

Rather than improving the Safety Fundamentals to address security issues, and inbreed such issues in the relevant IAEA standards, the IAEA established the IAEA Nuclear Security Series, a separate system of documents solely dedicated for nuclear security and which is not subject to the thorough review process of the system of safety standards.

The Nuclear Security Series somehow tries to mimic the safety standards series comprising:

(a) Fundamentals, claiming to contain the objectives, concepts and principles of nuclear security, providing the basis for security recommendations.
(b) Recommendations, claiming to present best practices that should be adopted by Member States in the application of the Safety Fundamentals.
(c) Implementing Guides, claiming to provide further elaboration of the Recommendations in broad areas and suggest measures for implementation.
(d) Technical Guidance publications including:
    — Reference Manuals, with detailed measures and/or guidance on how to apply the Implementing Guides in specific fields or activities;
    — Training Guides, covering the syllabus and/or manuals for IAEA nuclear security training courses;
    — Service Guides, which provide guidance on the conduct and scope of IAEA nuclear security advisory missions.

The Nuclear Security Series has been real mammoth effort by the IAEA. However, it seems to have been undertaken without a clear strategy and with a de facto objective of creating a separate 'family' of documents divorced from the traditional IAEA family of safety standards.

Recently, this situation is being improved and there is a possibility that finally the Nuclear Security Series will be integrated into the Safety Standards of the IAEA. This will be the starting of a new future for the security of radioactive sources.

4. TOWARDS A NEW FUTURE?

4.1. Promising developments

A number of promising developments are taking place in the IAEA.

The problems created by the safety vis-à-vis security conundrum were finally recognized by all IAEA Member States. In September 2012, the 56th regular session of the IAEA General Conference, by resolution GC(56)/RES/9 [23], acknowledged by consensus that safety measures and security measures have in common the aim of protecting human life and health and the environment. Moreover, it called upon the IAEA Secretariat to continue its efforts to ensure coordination of its safety activities and security activities, and encouraged Member States to work actively to ensure that neither safety nor security is compromised.

More recently, in September 2013, the IAEA General Conference, by resolution GC(57)/RES/9 [24], adopted at the 57th regular session, recognizes again that nuclear safety and security have the common aim of protecting human health, society and the environment, while acknowledging the distinctions between the two areas, and affirming the importance of coordination in this regard. It also encourages the Secretariat to continue implementing a coordination process to address interfaces between the publications of the Nuclear Security Series and the IAEA Safety Standards.

All these are encouraging developments at the level of the highest IAEA body. It is to be recognized, however, the General Conference continues to miss the fact that the issue is neither acknowledging obvious distinctions nor affirming coordination, but rather ensuring that safety and security become together. The main problem facing the IAEA in dealing with the safety vis-à-vis security confusion is not coordination or addressing interfaces, but rather embedding the security documents into the safety standards.

Another important development is that the IAEA Director General took the important decision of transforming the IAEA office dealing with nuclear security to a full division in the issue. This is very good news if the purpose is to reintegrate security into the traditional safety functions of the IAEA, but it would be terrible news if it divides further safety and security.

4.2. Remaining challenges

In spite of all the big achievements until now, the remaining challenges in the continuous global control of sources throughout their life cycle and in ensuring their safety and security are enormous:

— Legally binding obligations for States have not been established.
— International standards are few and incomplete.
— Security guidelines have been developed in isolation and their compatibility with the safety standards is dubious.
— An established international system for appraising compliance does not exist.

Bridging these gaps seems to be a sine qua non condition for ensuring internationally the safe and secure use of radioactive sources.

Change is underway in the IAEA with regard to the long standing objectionable separation between the IAEA activities on safety and security of radioactive sources, and this progress triggers optimism that the remaining challenges will be tackled. For instance:

- Coordination between the areas of safety and security has been increased.
- An ad hoc committee has been created under the structure of the Commission on Safety Standards (CSS) and its safety related committees.
- The IAEA Director General and the relevant Deputy Director General have emphasized on numerous occasions the importance of bringing these areas together.

These are all positive developments, but it should be realistically recognized that the international activities on safety and security of radioactive sources still remain two entities that basically appear to be foreign to each other.

5. EPILOGUE

5.1. Towards an international regime

The remaining major challenge for ensuring the safe (and secure) use of radioactive sources worldwide is the establishment of a serious international safety (and security) regime. Such an international regime should firstly include clear international intergovernmental undertakings of a legally binding nature. International undertakings are implemented by conventions and treaties (i.e. by formal agreement between States). They cannot be realized by 'codes of conduct' or other elements of 'soft' law, which are instruments that are neither a binding obligation nor a standard to be followed.

This challenge had been already recognized at the early Dijon Conference, which had by then concluded that it would be interesting to investigate further whether international undertakings concerned with the effective operation of national controlling systems and attracting broad adherence could be formulated. However, no progress had been made since then. The very much welcomed Code of Conduct, however important at the time of its approval, may have impeded the development of a legally binding undertaken.

The international regime should also include a system of coherent international standards: namely, an integrated and consistent set of requirements on the safe (including secure) uses of radioactive sources that need to be met to ensure the protection of people and the environment, both now and in the future. Its main purpose should be to ensure internationally that the control of radiation sources are not to be relinquished under any circumstance in order to **maintain**

the continuous global control of sources throughout their life cycle, which is the declared aim of the Abu Dhabi Conference.

Last, but not least, the international regime should include provisions for the application of these standards. This would require a full discussion on the disparate offer of appraisal services existing in the IAEA at this time.

5.2. Call for action

The international community is still far away from achieving a serious international regime for controlling the safety of radiation sources, including their security. Action is urgently required. The following are a collection of ideas for an action plan in this regard:

(1) The IAEA may wish to establish a committee to explore the possibility of drafting a Convention on the Safety and Security of Radioactive Sources on the basis of the existing Code of Conduct.
(2) The CSS of the IAEA may wish to launch a revision of the Safety Fundamentals to incorporate the relevant nuclear security fundamentals into them in a coherent and consistent manner. The revision is in any case much needed as they have become obsolete.
(3) An ad hoc committee for rationalizing the safety and security documents could be established to issue recommendations in this regard (e.g. it could be constitute d by the chair of the CSS and all safety and security committees).
(4) A committee should be established with the mandate of making a proposal for rationalizing all services offered by the IAEA under its statutory mandate of providing for the application of the IAEA standards at the request of a State.

Action is the process of doing something to achieve an aim: the time is ripe for doing something concrete for the safe (and secure) use of radioactive sources.

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TOWARDS SUSTAINABLE NUCLEAR SECURITY

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Abstract

The paper has three parts. It will first of all briefly trace the development of the current threat of nuclear terrorism that has created the need for a global capability in nuclear security, focusing on radioactive sources. It will then briefly assess the work that has been done internationally, by the IAEA, States and others to meet the threat. Having outlined the need for security of radioactive sources, the final and main part will propose ways of ensuring that the global capability can be assured into the future.

1. INTRODUCTION

There is every reason to think that the threat of nuclear terrorism may continue for at least a generation: in excess of a further 25 years. Therefore, it remains clear that we need a sustained global protection capability in order to ensure balanced protection of all States.

There has been a wide and extensive effort by the IAEA and other organizations and Member States that needs to be acknowledged [1–3]. Extensive investment at the national, regional and international levels by some States and regions in facility hardening is particularly notable.

With the downturn in the global economy and with evidence that some progress has been made, it is hard to see how a case could be made to maintain the levels of expenditure and protection we have seen over the past ten years. So how do we continue to protect radioactive sources, ourselves and our colleagues in other States? How do we ensure that all the good work that has been done, continues to add value to local endeavours, and at an affordable cost and lasting for more than 25 years? The answer is surely in educating and training our experts to a consistent suitably high and shared standard. We need to emulate the good work that has been done by our safety colleagues over decades. The key concept is the ‘professional’, as defined in the paper.

The proposition is that this requires the training and development of professionals in nuclear security who provide specialist advice to governments, regulators and operators and who appreciate and apply the synergies of security and safety. Furthermore, safety and security need to be thought of as two sides of the same coin. Success in the future depends on successful integration of safety and security cultures by professionals.

The 'professionalization' of nuclear security may perhaps best be achieved by emulating the now well developed global approach of radiation safety: entrusting and empowering the development of the nuclear security profession to its members by the creation of national (or regional) level professional societies or associations. This will bring radioactive source security specialists into contact with their more experienced nuclear fuel cycle security colleagues. It will provide a forum for young professionals to learn from their more experienced colleagues and their peers, and it will enable professional development at the international level. Additionally, assigning responsibilities to those professional societies to oversee the continuous professional development of their members, and to liaise internationally, will create a shared professionalism. And professionals (by definition) are self-sustaining.

The physical protection/security of nuclear material and nuclear facilities has, since its conception, had to develop in response to the ever changing and increasing threats. It is now a highly mature field, dating virtually from the inception of the nuclear age, with longstanding international requirements and guidance. More recently, those concerned with the security of radioactive sources have been fortunate in being able to turn to the considerable body of knowledge and expertise of the established nuclear security industry when developing the thinking required to protect against new and emerging threats.

In this way, excellent work has been undertaken by organizations such as the IAEA, the World Institute for Nuclear Security (WINS), US and Australian agencies and others, to enhance the protection of significant radioactive sources in various parts of the world [2]. The United Kingdom has also been a contributor to international efforts both directly, via the Government's Global Threat Reduction Programme [4] and also via contributions to the IAEA Nuclear Security Fund.

The United Kingdom has also put a lot of effort into establishing a statutory national scheme for the security of radioactive sources, which was conceived in 2002 and fully emplaced by 1 January 2006 [5]. This has been a challenging regulatory programme but a lot of insights have been gained. These insights have been further developed by the use of radiation safety specialists for radioactive source security, resulting in some synergies. In particular, there has recently been an initiative to encourage professionalization of nuclear security in the United Kingdom that was stimulated by involvement in professionalization of radiation protection [6]. Lessons learned that relate to sustainability of nuclear security will be shared in this paper.

2. A BRIEF HISTORY

Looking backwards from 2013 over a long career as a nuclear regulator in the United Kingdom, it seems barely credible that before the awful events of 11 September 2001, regulatory inspections of users of radioactive sources were cursory [7]. At that time, the need to keep sources in locked storage was recognized but primarily for reasons of safety, and not security, as the concern was that no one could inadvertently and unwittingly access them, or even remove them. But a 'decent lock' and a 'strong chain' passing through a refrigerator handle usually met the regulator's expectations. There was no defined security standard, nor any perceived regulatory need for one. Perhaps once in a career, a regulator might encounter something potentially sinister about a case involving what we now call 'orphan sources', but these things usually resolved to a causation rooted in negligence and incompetence rather than malicious intent.

It is clear now that security services have been for some time aware that 'terror organizations' (the potential adversaries) were making efforts to acquire radioactive sources, but (even though some of this was occasionally reported in the media), the public and most regulators remained ignorant of this particular change in the threat. In the United Kingdom at least, radioactive substances regulators and security services were not routine colleagues (as they are today): their paths rarely, if ever, crossed.

The idea of potential adversaries acquiring nuclear materials was more widely recognized: the break-up of the former Soviet Union raised the spectre of nuclear weapons falling into the wrong hands, and potentially being diverted to malicious use. This was credible and a source of some governmental and media anxiety. And there were occasional 'scams': fraudulent 'marketing' of what were (in nuclear terms, if not chemically) inert materials that were purported to double as special nuclear materials. 'Red Mercury' was probably the most well known of these. But radioactive sources as a weapon? No! And even if anyone (probably in the nuclear weapons field or security services) contemplated a radioactive source scenario, it would probably have been dismissed on the apparently rational argument that almost any radioactive sources had such a small capacity to harm compared to a nuclear detonation that they could be ignored. It was even the case that some colleagues, in the earliest days of responding to the potential threat of radiological terrorism, dismissed radioactive sources as constituting a significant hazard on the grounds that their potential for causing harm is trivial compared with the harm caused by a nuclear weapon detonation or a successful attack on a reactor by a hijacked aircraft. They were partially correct of course; but what these few did not realize at that point was that, although radioactive sources were relatively low in source strength, they were strong enough to cause sociopolitical disruption which was out of proportion to the radiological harm to health and only loosely related to source strength. Even trefoil warning tape could (and this is still the case today) close a highway or a business district, if only for an hour or two before they were properly assessed.

The potential for 'illicit trafficking' in radioactive sources had been long recognized by the IAEA [8]. The notion of radioactive sources being lost was well established based on many experiences around the world. In addition, the prospect of sources being bought and sold outside of regulatory control or of radioactive waste being trafficked to avoid fees and charges for proper disposal were anticipated but probably never realized on any significant scale.

The United Kingdom established the Orphans Sources Liaison Group (UKOSLG) as a result of an INTERPOL initiative that emerged as a result of a joint IAEA, European Commission, INTERPOL and the World Customs Organization conference held in Dijon in 1998. The output was published as IAEA-TECDOC-1045, Safety of Radiation Sources and Security of Radioactive Materials [9]. (This was the first of this kind; Abu Dhabi is the latest). The primary business of the UKOSLG was to coordinate interests across government, industry and the police service about sources that turned up inadvertently in inappropriate places, usually the scrap metal supply chain. UK security services participated, listened intently, but shared little.

On one occasion, that group discussed theft of sources used in panoramic irradiators and the conclusion was that this was not a credible scenario. The high activity of such arrays meant that they were deemed to be 'self-protecting': no one in their right mind would try to steal them, nor could they, as the radiation exposures would be so extreme that neurological symptoms of acute radiation sickness would quickly occur, and overwhelm the thief. In short, it could not happen: no adversary could even consider dying to divert these sources. This was the received wisdom of the time.

On 11 September 2001, the fact that some adversaries were prepared to die for their cause became clear. Security agencies began to realize that if a line of volunteers were required to steal high activity sealed sources, then such a line of people could reasonably be expected to be mustered. This changed the global picture. This is when the world started to recognize the significant potential for adversaries to divert radioactive sources so that they might in some way be 'weaponized'.

Although the tragic events of 11 September 2001 brought the concept of international terrorism sharply into focus for the public, the IAEA and national security services already had evidence that terrorists had been actively trying to acquire radioactive sources to make a weapon — the so called ‘dirty bomb’ — since the 1990s [8]. And yet remember: at that stage, there had not been a meeting of minds (at least in the United Kingdom) of the security services and the regulators, the public and the media. Regulation of the keeping and use of radioactive sources was based upon the well established Basic Safety Standards (BSS). ‘Security of sources’ in those days meant protecting them from accidental access, loss or inadvertent unwitting petty theft. The worst case scenarios of the day were the potentially serious consequences of sources lost from regulatory control and discovered in inappropriate places, like the scrap metal supply chain. The tragic events of the Goiânia radiological accident [10] demonstrated how bad such an accident could be, but the new challenge was beyond the experience of most of us. So governments, regulators and operators therefore needed more support, beyond the BSS. It was also clear, and remains so, that we need a global protection system in order to ensure balanced protection by all States.

What was driving this change of policy? What evidence was there beyond that which showed that adversaries would be willing to die in an attack in the name of a strong enough cause?

The leader of al-Qaeda, Usama bin Laden, had never directly stated his interest in using radioactive material in terrorist acts prior to 1999. However, in a 1999 Time magazine interview he stated that “acquiring weapons for the defence of Muslims is a religious duty … and if I seek to acquire these weapons, I am carrying out a duty” [11]. In 2004, the 9/11 Commission Report noted “al Qaeda has tried to acquire or make nuclear weapons for at least ten years” [12]. While the possibility is low, a radioactive dispersal device could result from a failed attempt to make a nuclear device. In addition, Dhiren Barot was jailed in the United Kingdom in 2006 for conspiring to murder using an improvised radiological device [13]. What could have been the consequences if either of these people had successfully deployed a radiological weapon?

A number of radiological accidents have occurred in different parts of the world. The consequences of these accidental dispersals of radioactive materials were sufficiently serious to demonstrate that (contrary to the previous view) the illegal dispersal of radioactive sources could have significant impact. Perhaps the best known of these accidents was that in Goiânia, Brazil, in 1987, when a radioactive source no greater in diameter than a one euro coin was naively disrupted [10]. Four people died, but 112 000 people came forward for reassurance monitoring and 3500 m^3 of radioactive waste was generated in decontaminating the affected area. It has been reported that it took the city over ten years to recover its socioeconomic equilibrium after the remedial work was completed.

This accident is often used as a model of the potential consequences that could result from a deliberate use of radioactive sources as a weapon. The consequences at Goiânia were all unintentional: there was no mens rea trying to cause harm; no design, no driving malicious purpose. And yet the consequences were so significant. What could have happened if there was careful planning, what an adversary might call ‘optimization’ of the harmful consequences?

Some may argue that ‘safety’ was already dealing with the security of sources issues long before 11 September. Others may say that this event only magnified the work on security that was already being done by safety specialists. Yes, there were one or two IAEA conferences on sources prior to then, but they were dominated by orphan source issues that largely were about negligence on the part of holders, rather than deliberate malicious acts that we now must face up to. Yes, 11 September did bring greater attention to an issue that was already being discussed, but what that event did trigger was a global realization that **not enough** was being done and that a greater emphasis on security was needed; not as a subset of safety but as a partner to safety providing another complementary critical element of protection and control. We need to look forward, and we need to integrate our thinking (as safety and security practitioners) to enable us to succeed in rising up to meet a significant threat: malicious use of radioactive sources by a determined adversary.

The need for sources to be protected against malicious acts has therefore never been more necessary. We have started, but there is a lot more to be done.

3. INTERNATIONAL EFFORTS TO IMPROVE SECURITY OF SOURCES

There is not space here to provide a detailed description of what has been done and achieved by international efforts to improve the security of radioactive sources. Instead, some examples of work that has been undertaken will be listed in order to demonstrate both the amount of effort already expended and the implied importance that States have assigned to this work.

The IAEA has provided an international lead in this respect, with the Nuclear Security Plan. The next version covers the period 2014–2017 [14]. One of the key events in previous versions was the creation of the Code of Conduct in the Safety and Security of Radioactive Sources [15]. To date, about 120 States have now written to the IAEA Director General to express their support for the Code and their intention to implement the principles it contains [16]. As a result:

— Numerous States have established bilateral programmes to provide assistance in improving security for radioactive sources [17].
— International guidance specific to radioactive material security has been published and continues to be developed, notably the Nuclear Security Fundamentals and Recommendations, and the Nuclear Security Series.

The Nuclear Security Guidance Committee continues to oversee these and other documents.
- Security of radioactive sources is included as a key point at the Nuclear Security Summits.
- A regional partnership for improving source security has been established in South East Asia [18];

And we could note, for example, the considerable efforts expended by the Global Threat Reduction Initiative, in the United States of America, and the Global Threat Reduction Programme, of the United Kingdom. There are other programmes not mentioned here.

It is clear then, that there has been a considerable amount of investment and effort that needs to be supported into the future, to meet a threat expected to last at least a generation. A key component of how this may be done is described in the next section.

4. TOWARDS SUSTAINABLE NUCLEAR SECURITY

This part of the paper could be presented in a one sentence proposition:

> Even with extensive investment in hardening projects around the world, sustainability of nuclear security can only be assured if suitable investments are made in developing competent professionals to satisfy the State that suitable standards of security will be sustained over time.

Concise as it is, this sentence does deserve some explanation. As is traditional, this will be done partly by defining terms. For now, simply note that the key term in this sentence is: “professionals”. We will return to this pivotal term in due course and at some length, but it is best to dispose of some of the other (easier) terms first.

Little may be thought to be required to define the term ‘nuclear’, but in some countries the word is used in a more restrictive way than that used in the IAEA vocabulary. So, for readers in the United Kingdom and Pakistan if nowhere else, in this paper the term “nuclear” includes radioactive sources as well as special nuclear material and associated facilities.

Security is defined by the Oxford English Dictionary as “the state of being free from danger or threat”. This really does not help very much. In trying to do better for this paper, a great deal of thought went into trying to distil out the essential meaning of the words ‘safety’ and ‘security’. It proved to be surprisingly difficult: in Russian, French and Spanish only one word is used to describe both safety and security. The best that could be achieved was:

- — Security is about striving to prevent unauthorized access to something.
- — Safety is about striving to ensure that no one is exposed to unacceptable levels of hazard, whether they are authorized to access them or not.
- — Security is about striving continuously to protect against a rare event — an attack by an adversary.
- — Safety is about striving continuously to protect against a frequent event — changes in exposures to radiation from activities that if left unchecked could sometimes be hazardous (and sometimes rarer events we call incidents).

In the end, the conclusion was that safety is about **protecting humans from radioactive sources** and nuclear security is about **protecting radioactive sources from humans**.

If radioactive material is not secure, safety will be compromised; if it is not safe, then it **really** needs to be kept securely. This simple reasoning will have to suffice for now, but experience shows safety and security cannot be operationally separated. They need different types of expertise and they are best applied synergistically. That synergy can only reliably be achieved if safety and security professionals work well together. This means working closely together and integrating their thinking, understand something of each other's vocabularies, concerns, methods, constraints and metrics, and committing to finding the balance between the two disciplines in order to realise the synergies.

Of course, there are 'grey areas' between the two: security and safety tend to 'shade' into each other at the margins of the ideas. But the essence of it is cultures of safety **and** security. Neither of them is absolute. They are risk based because they have a probabilistic component. Nothing is ultimately safe and nothing is ultimately secure. That is why the word 'striving' features in the attempt at distinguishing safety and security provided above. But both are essential.

You cannot have one without the other. Security cannot be so tight that safety is compromised; it has to ensure that safety measures are not disrupted, neither at the location in which they are usually applied, nor are they able to be disrupted at another location where they may later be used to do harm.

One of the views expounded in this paper is therefore that safety and security are semantically closely related concepts and in this treatise will be considered to be 'two sides of the same coin'. They are different, but they are closely and inextricably associated with each other, and mutually dependent.

Having defined the terms, we should move on to the main thrust of the argument. It has already been argued that 'hardening' of physical protection alone provides security, but it does not deliver **sustainable** security. Competent people deliver that. Let us now consider who these people are and what their competences are.

Achievement of effective nuclear security can be compared to making a cake. You need all the ingredients to successfully achieve your objective. The baking tin is the hardware. The objective is a cake. In nuclear security, the people (nuclear security specialists) are the ingredients and include:

— Engineers;
— Designers;
— Analysts;
— Guards;
— Managers;
— Policy makers;
— Contractors;
— Regulators;
— Other personnel.

Some of these who will become security personnel will typically (at least in the United Kingdom) have a military background (from preventing unauthorized access to weapons), a police background, a commercial background (such as a retired member of a security service) or will be general managers. This diversity enriches the pool of knowledge and experience. It makes a better cake.

Each of these disciplines is an ingredient in our cake. Leave one out and it will not please us: it will not be cake; it will not be effective nuclear security. Many of the best cakes have been created unintentionally: a happy accident in which the skills of the baker successfully pulled all the ingredients together. Could it be that nuclear security is a bit like this? Is its current organization and effectiveness in part a happy accident? What can be done to be more systematic in developing nuclear security specialists?

It may be provocative to say so, but the contention is that even in the nuclear fuel cycle industries, it seems that the body of security specialists as a group have evolved more by accident rather than design. This proposition has been tested in the United Kingdom, and there has been no argument in response from a wide range of nuclear security practitioners and regulators. It is clearly evident that security of radioactive sources being a relatively new (and still emerging) discipline is even less well 'baked'; it is not yet fully mature.

Yes, there is currently a large body of binding international agreements and extensive knowledge. Yes, the system generally works (but not always). A colleague has suggested that a well developed security culture holds all the ingredients of nuclear security together, and this appears to be the case. But is it enough? Is it **demonstrably** enough? Security culture is another vital ingredient, but will it alone provide sustainable nuclear security? Is security culture itself sustainable? Can nuclear security regulators be satisfied that there will be continuous improvement? If there is a major failure, and an enquiry at the political level, will governments and the media say: was there an appropriate level of coherence in the personnel; was there professionalism in place to prevent the failure? The answers are all no, and a vision of what is now needed will be expounded from here onwards. The principle (in summary) is: there are very many experts in nuclear security, but (by the definition used in this paper) they are not yet **professionals**.

When we go forward — and go forward we must — and we start to combine terms, it becomes apparent that further definitions are required.

Nuclear security has two slightly different but complementary interpretations. One is the **outcome** of the implementation of those processes that means that society is satisfied that nuclear materials are suitably safe: society is free from danger or threat. And the other is the rich 'cake' with ingredients of science, engineering, management, criminology, political science, policies and a variety of cultures that have led to the development of policies and processes: the embodiment of nuclear security as a discipline (or a **profession**). The route to sustainable security depends upon professionalization of the people involved.

5. PROFESSIONALIZATION AS A ROUTE TO SUSTAINABILITY

Let us now turn to this key term in our one sentence proposition: **professionals**. It is the key term because it underpins the vision to enable us to move towards sustainable nuclear security.

The word profession is defined in many international dictionaries as something like a type of job that requires special education, training or skill. This is not the way the term will be used in this paper. Instead, a more traditional definition that is still used in some circles in the United Kingdom will be adopted.

The origin of the word is from the Latin *professio*, from *profiteri* 'to declare publicly'. It derives from the notion of an occupation that one 'professes' to be skilled in. Traditionally, a profession in the United Kingdom was a job that requires special education or training, and involved direct payment of a fee by the customer (see para. 123 of Ref. [19]). (This United Kingdom centric analysis does have merit; please accept it for now as the basis for a recommendation to the international nuclear security profession.)

The scope of the professions therefore traditionally extended to work by doctors, lawyers, architects and accountants. Today in the United Kingdom, there are many more types of professional, including radiation protection professionals who are recognized by the State [20], but the connotations of the term ‘professional’ still exist.

The key defining feature of the high status professions previously listed is that they are regulated, either by statute, or by self-government with reference to a code of conduct (sometimes by a mixture of both). If a profession has this, they are deemed by the State to be worthy and to be allowed to “profess to be skilled in” their work [20].

So in the United Kingdom and often elsewhere, professional **status** in any discipline is recognized as applying to those who practise certain academic disciplines by those who use the services of those practitioners (such as the clients of lawyers and the patients of medical practitioners) because of the perceived competence of the practitioners in doing their job and their objective behaviour while doing it. Note that emotional attraction to, and enthusiasm for, that job have nothing to do with professionalism — worthy as they may be in encouraging devotion to that job [20].

In many (though not all) parts of the world, another characteristic of the above mentioned professions is that the practitioners are members of a ‘professional institution’ or ‘professional association’ of some kind. Sometimes membership of this kind may be custom and practice, but very often it is a mandatory requirement, enshrined in law or at least policy.

The institutions, of which the professional practitioners are members, are the vehicles by which their members (of the various backgrounds provided in Section 4) can ensure that competence and objective behaviour in performance are regulated. What is important in encouraging professional competence and right behaviour is the regulatory powers of the professional institutions, namely:

— A self-governing profession where standards to begin and to continue professional practice are set by the members of the relevant professional institution.
— A code of professional conduct is imposed by a membership or registration contract on all practitioners who are required by statute to join the professional institution that has the power so to impose.
— A component of the code of professional conduct being a commitment to continuous professional development.
— A disciplinary procedure established by the professional institution and operated largely by its members so that it will enquire into any complaint lodged about the professional competence of the practitioner (not including, of course, criminal behaviour, which is a matter for the courts of law although the institution would expect to remove from the practising register anyone convicted of a crime that was relevant to the practice of the profession) [20].

Recall that the ‘professional institution’ was previously also synonymously termed a ‘professional association’. With no apologies for more definitions, ‘association’ means a group of people organized for a joint purpose — a club, if you will. It can also mean the act of associating. Practitioners who associate with colleagues who have different backgrounds learn from each other and develop each other. They may do this by sharing structured training and development events: conferences and courses; but they also realize less formal development opportunities. They mentor each other. They meet people and make friendships and professional relationships. This means they can turn to each other for professional support. They can learn something new over a cup of coffee, over the phone or at a social event organized by their professional institution, should they be so inclined. How else will the various ingredients of our nuclear security cake be mixed together if there is no professional association?

The final proposition is this: the professional route is the way to provide sustainable nuclear security. What does this mean in real terms?

It means to encourage each State (or region if the profession in a single State is too small on its own) to create a national professional body for nuclear security specialists the role of which is:

- To set national standards for competence in nuclear security consistent with international best practice as defined by IAEA documents (aimed at governments and regulatory bodies) and WINS (aimed at operators and hence the profession);
- To accredit (meaning to attribute quality to) national training courses in nuclear security at entry level and for continuous professional development;
- To develop and impose (by registration contract) a professional code of conduct (meaning the behaviours of a professional individual who is effective and suitable for the tasks of prescribing, designing, installing, managing and sustaining nuclear security measures);
- To create and implement a disciplinary procedure operated by the members of the professional body;
- To create a register of certified nuclear security specialists by issuing those who are demonstrably competent with a certificate or licence;
- To assure that standards of competence will be maintained by periodic revalidation of the competence of nuclear security specialists on the register;
- To govern the profession by peer review provided by members of the professional body;
- To facilitate international minimum standards of implementation by professional collaboration via an international level professional association.

The prompt reaction of some to these proposals may be scepticism or even rejection: it cannot be done! That is manifestly not the case: our radiation protection (safety) colleagues have achieved all of this (granted not in every State, but the number involved is growing) [21]. Why can't we nuclear security practitioners?

In radiation protection, standards are set by recommendations of the International Commission on Radiological Protection and the BSS,[1] which then implement those recommendations. At regional (e.g. the European Union) and State levels, the BSS are reflected in national radiation safety legislation. In radiation protection, the BSS require the establishment of regulatory bodies and the recognition by these regulators of radiation protection experts (RPEs, formerly called qualified experts) [22]. And at least 60 States have subscribed to a professional association of radiation protection specialists [21]. Membership is often dependent on achieving recognized qualifications in radiation protection, and in some cases, progression up the membership structure (and therefore up the professional hierarchy) may be achieved by the acquisition of experience and the acceptance of responsibility within the profession (supporting the association, taking on management or training/development responsibilities).

So if this can be done in radiation protection, why can't it be done in nuclear security?

In the United Kingdom, there is a move in this direction. The University of Cumbria is at the centre of a move towards professionalization of nuclear security in the United Kingdom, based on insights gained from the relatively recent professionalization of radiation protection following the recognition by the State of the professional society. An industry focused MSc in nuclear security management is in development and a professionalization movement is being encouraged [6]. This will be by engaging with the nuclear regulators (Office for Nuclear Regulation and the environment agencies), local nuclear licensed sites, international organizations (including IAEA International Nuclear Security Education Network and WINS) and the radioactive source users. External contributions to the MSc enable professionals to share their knowledge in a way that simply does not exist in the United Kingdom at present. And the professionalization movement will draw in more and more practitioners and enrich the pool of knowledge and experience and improve consistency and above all: sustainability.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GRS Part 3 (Interim), IAEA, Vienna (2011).

There is no intention to set up a new professional association in the United Kingdom, but negotiations are underway to develop a nuclear security constituency in an association that already exists: The Security Institute. This already serves the wider security industry and is recognized by the State (by virtue of its legal status as a corporation and its operation of a professional register). The hope is that this organization will form a new constituency (a subdivision or 'chapter') specifically to serve, support and regulate a new nuclear security profession. This is a work in progress, and when success is achieved, it will be reported elsewhere.

Who are the people to direct this educational resource and professionalization drive?

— Nuclear security professionals in industry;
— RPEs (previously known as qualified experts) in industry;
— Regulators;
— Police and security services;
— Customs and immigration where radiometry is in place at national borders;
— Government policy makers (who perhaps may choose to major in other subjects than physical protection technologies);
— Graduates, or suitably experienced individuals, wishing to embark on a career in nuclear security.

The aim should be to produce specialists to do this work, not generalists. The term 'specialists' does not necessarily mean that individuals should only be competent in one narrow subject; but experience suggests that this is not a job for generalists, whose competence is limited to following a tick box list of 'things to check'. The challenges of radiation protection and nuclear security both require a significant level of competence. Regulators at least (but probably many operators too) will recognize that unusual cases occur from time to time. When they do, a fully developed professional will be able to either apply what they know to solve a novel challenge or recognize when they need additional support, since professionalism includes knowing what you do not know. The analogies with radiation protection are hopefully clear.

6. CONCLUSIONS

A lot of money has been spent on the security of radioactive sources since 11 September 2001, and for good reason. We might describe this effort as 'protecting radioactive sources from humans', (whereas safety is about protecting humans from radioactive sources). The consequences of a security failure could be very significant, causing harm to health and socioeconomic and political damage that is likely to be disproportionate to the physical dimensions of the hazard.

For this reason, safety and security specialists need to work closely together and integrate their thinking, understand something of each other's vocabularies, concerns, methods, constraints and metrics, and commit to finding the balance between the two disciplines.

There is a lot of valuable knowledge and experience 'out there'. It is deployed in protecting nuclear sites and radioactive sources and comprises of security specialists who are expert, but who are not yet 'configured'; they are not yet linked to each other in a way that means that they **systematically** share their knowledge with their younger colleagues; they do not yet set standards, nor can they ensure those standards are met, by teaching and professional development. And they are not properly linked to their less established colleagues who specialize in radioactive source security. Commonly, neither are they integrated with their safety colleagues — the other side of the safety/security coin. It is suggested that the best way to achieve all this is to encourage each State to create a national (or regional) **professional body for nuclear security** specialists. This is where the culture will be sustained; this is where the competences will be sustained over time; this is how continuous improvement will be achieved. This is what **professionals** do.

And professionals (by definition) are self-sustaining.

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TEN YEARS OF IMPLEMENTATION OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES: ACHIEVEMENTS, CHALLENGES AND LESSONS LEARNED

(Session 2)

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RAPPORTEURS' SUMMARY

Session 2: Ten Years of Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources: Achievements, Challenges and Lessons Learned

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The objective of this session was to celebrate the ten year anniversary of the Code of Conduct approval by the IAEA Board of Governors, by recalling its history, from drafting to implementation and by presenting regional overviews of the 67 national reports submitted by States for this Conference. Indeed, as announced in the official invitation, this Conference session, in effect, served as the third open ended meeting of technical and legal experts to share information on States' implementation of the Code of Conduct and its supplementary Guidance on the Import and Export of Radioactive Sources (Guidance), in accordance with the formalized process established in 2006. All national reports authorized for publication are in the CD-ROM of these Proceedings. To provide more time for in-depth and bilateral discussions on experience and challenges in implementing the Code of Conduct, States were invited to prepare a poster on their national reports, and a dedication poster session took place in the course of the Conference. In addition, the session provide an opportunity to present a recent survey made by the European Union recently on the implementation of Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources.

The historical overview first outlined the development of international concern regarding the safety of radioactive sources in the 1990s, leading up to the development of a Code of Conduct in 2000. The extensive revision of the Code of Conduct in 2002–2003 was then discussed, in particular for considering the increasing security concerns after the events of 11 September 2001. The process by which a questionnaire was circulated to Member States in early 2002 to identify the strengths and weaknesses of the Code of Conduct as well as to gain understanding of its implementation and other improvements that were considered necessary was presented. Finally, the additional efforts leading to the development of the supplementary Guidance in 2004 (published in 2005) and its revision in 2011 (published in 2012) were also discussed.

The wide endorsement of the Code of Conduct by a large number of States and a range of international institutions and conferences over the decade since its formulation was recognized as a very positive achievement. Major successes of the Code of Conduct over the past ten years were highlighted, including the successful information exchange through a voluntary process, as well as national and regional initiatives. However, it was also recognized that there are still important challenges facing the international community with regards to implementing the Code of Conduct, particularly all those relating to the long term management of disused radioactive sources. These challenges have financial and technical dimensions and include transport issues (denial of shipment and lack of certified containers), waste management policy and strategy (interim versus long term storage, and disposal options) and liability issues for legacy sources management.

The four regional presentations provided some more insight into the achievements and challenges reported by States in their national reports, addressing part or all of the suggested topics of the formalized process, namely:

(a) The infrastructure for regulatory control;
(b) The facilities and services available to the persons authorized to manage radioactive sources;
(c) Training of staff in the regulatory body, law enforcement agencies and emergency service organizations;
(d) Experience in establishing a national register of radioactive sources;
(e) National strategies for gaining or regaining control over orphan sources, including arrangements for reporting loss of control and to encourage awareness of, and monitoring to detect, orphan sources;
(f) Approaches to managing sources at the end of their life cycles;
(g) Experience with arrangements for implementing the import and export provisions of the Code of Conduct (paras 23–29) and the Guidance;
(h) Any other issues relevant to the implementation of the Code of Conduct and the Guidance.

However, it was clearly stated that the scope and level of details provided in national reports vary a lot, which makes it difficult to derive precise conclusions on the level of implementation of the Code of Conduct.

The session ended with a general agreement that additional guidance should be provided to States for preparing their national report, so that a comprehensive self-assessment against all provisions of the Code of Conduct could be done, leading to a more complete and homogeneous reporting process.

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THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES
Past, present and future

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Abstract

The non-legally binding IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code) forms the basis for national regulations and international guidelines on the protection and management of radioactive sources globally. The paper outlines the history of the Code, starting with the international concern regarding the safety of radioactive sources in the 1990s that led to the development of the initial Code in 2000. It discusses the impact of the events of 11 September 2001 and rise in security concerns that brought about the extensive revision of the Code in 2002–2003 and development of the associated Guidance on the Import and Export of Radioactive Sources in 2004. It describes the growth in international recognition and endorsement of the Code and Guidance, including the political commitments made by 119 States to follow the Code and by 84 States to follow the Guidance, to date. The paper describes the successes of regional and bilateral cooperation activities and the establishment of a formal review mechanism that includes triennial IAEA information exchange meetings. The paper concludes by discussing important challenges still facing the international community ten years after the endorsement of the Code by the IAEA General Conference, particularly those relating to the management of disused sources.

1. HISTORY OF THE CODE

In 1998, the first mention of an international undertaking was made at the Dijon Conference on the Safety of Radiation Sources and Security of Radioactive Materials, albeit in rather tentative terms (p. 364 of Ref. [1]):

> "It would be interesting to investigate further whether international undertakings concerned with the effective operation of such national systems and attracting broad adherence could be formulated."

The recommendations of the conference were taken forward by meetings of technical and legal experts in 1998–1999. Those meetings produced the IAEA Action Plan on the Safety of Radiation Sources and Security of Radioactive Materials [2], which was endorsed by the Board of Governors and General Conference in September 1999. One of the actions in the Action Plan was "to initiate a meeting of technical and legal experts for exploratory discussions relating to an international undertaking" [2]. That undertaking should address:

- Establishment of regulatory infrastructures;
- National arrangements for prompt reporting of missing sources;
- National systems for ensuring appropriate training of personnel;
- National arrangements for management and disposal of disused sources;
- Arrangements for response to the detection of orphan sources.

Consequently, meetings of legal and technical experts were held in March and July 2000. Those meetings — which were attended by representatives of only a small number of States — produced the Code of Conduct on the Safety and Security of Radioactive Sources. The objective of the Code was: "To achieve and maintain a high level of safety and security of radioactive sources through the development, harmonization and enforcement of national policies, laws and regulations and through the fostering of international co-operation":

- It covered essential administrative matters.
- It applied to sealed radioactive sources (it was felt that the application of the Code to unsealed sources risked a loss of focus on the most serious safety threat).
- It was addressed to States, not manufacturers, suppliers, users (it was felt that the most urgent issue was the development of appropriate regulatory systems).

— It allocated the main responsibility for safety to the State in which the source was located (there was no consensus regarding any commitments by States exporting sources).
— It was a non-binding document (there was no consensus in the Expert Meetings to take it any further).

A number of provisions of the 2000 Code were relevant to maintaining control over sources. Some of those provisions explicitly referred to the needs of “security”. However, the focus of those provisions was on incidents such as persons stealing shiny objects for scrap metal resale. No consideration was given at that time to possible use of sources in radiological dispersal devices or other malicious devices.

Following the completion of the Code in July 2000, the Board of Governors requested the Director General to organize consultations on the application and implementation of the Code and make recommendations to Board. The 2000 General Conference invited Member States to take note of Code of Conduct and to consider, as appropriate, means of ensuring its wide application. At that stage, the Code of Conduct could have become a document of little practical relevance.

However, there were two factors that ensured that would not happen. The first was the decision of the IAEA Secretariat to use the Code of Conduct as a basis of its regulatory assistance to developing countries. The second was the momentous events of 11 September 2001.

After the terrorist attacks, radioactive sources that were primarily considered a safety concern in the past were now considered to present a security risk. Radioactive sources could be used to build a radiological dispersal device, or ‘dirty bomb’ and use of such a device could incite widespread panic, cause illness, increase cancer risk, contaminate large areas, result in evacuations, and severely disrupt the economy. As a result, there was a shift in international nuclear security efforts to include the security and protection of radioactive materials.

2. EFFORTS TO STRENGTHEN THE CODE FOLLOWING THE EVENTS OF 11 SEPTEMBER 2001

Improving the security and control of radioactive sources in the aftermath of the events of 11 September 2001 was a challenge. Radioactive sources are ubiquitous — they are used in nearly every country for beneficial purposes in medical, industrial, agricultural and research applications. Many of these sources were poorly secured during use, storage, and transport and unknown numbers of lost, stolen or abandoned radioactive sources existed worldwide.

2.1. Questionnaire

In early 2002, the Secretariat sent a questionnaire on the Code to Member States to solicit information on how best to strengthen the Code of Conduct to address emerging radiological security concerns. That questionnaire was in four parts:

(1) Administration of the Code: to establish the extent of formal acceptance of the Code by Member States.
(2) Strengths and weaknesses of the Code: questions on each part of the Code.
(3) Specific issues arising from the Chairman's Report of the July 2000 meeting, which noted a number of areas where consensus had not been achieved:
  - Should the scope of the Code cover radiation generators?
  - Should there be provision for the establishment of national registries?
  - Should there be an international source register?
  - Should exporting States assume some responsibilities for ensuring that sources are safely and securely managed in recipient States?
  - Should the Code be converted into a legally binding instrument?
(4) An assessment of the overall impact of the Code, and some questions regarding possible additional provisions:
  - Has the Code improved the situation of the safety and security of sources in your country?
  - Is more provision for security needed?
  - Should the Code differentiate existing sources from new ones?
  - Should the Code contain provisions as to third party liability?
  - Are there any other changes which are desirable?

2.2. Revision of the Code of Conduct

Taking the results of this survey into consideration, the IAEA convened three technical meetings in 2002–2003 to revise the Code of Conduct to more adequately address security concerns. Revisions to the Code elaborated on and added provisions relevant to physical protection and security, and to further strengthening safety, including access controls, national registries, training, notification requirements, orphan source recovery, import/export guidelines, emergency planning, inspections and enforcement. One key part of the Code is the categorization contained in annex 1 that lists 16 radioisotopes commonly used in radioactive sources that could cause serious harm if not safely managed or securely protected. This categorization has formed the underlying basis for the development of international guidelines, bilateral and multilateral assistance efforts, and the application of national safety and security measures for radioactive sources worldwide since publication of the revised Code.

The revised Code gained substantial international support. The 2003 International Conference on the Security of Radioactive Sources in Vienna helped crystallize international support for strengthening the Code to more fully address security. One of the two major findings of the Conference stated:

> "Effective national infrastructures for the safe and secure management of vulnerable and dangerous radioactive sources are essential for ensuring the long-term security and control of such sources. In order to promote the establishment and maintenance of such infrastructures, States should make a concerted effort to follow the principles contained in the Code of Conduct on the Safety and Security of Radioactive Sources that is currently being revised …" [3].

In a further show of support, at the 2003 G8 Summit in Evian, G8 leaders urged "all countries to take measures to strengthen regulatory control of high-risk sources within their territories" and to "observe the Code of Conduct when the revisions to it have been completed and approved" [4].

The revised Code was approved by the IAEA Board of Governors in 2003 and published in 2004 [5]. Importantly, at the 2003 IAEA General Conference, Member States included in Resolution GC(47)/RES/7 a call for States to make a political commitment regarding the Code. Specifically, the General Conference:

> "Urges each State to write to the Director General that it … is working toward following the guidance contained in the IAEA Code of Conduct …" [6].

While the Code is not legally binding, this General Conference resolution provided a mechanism for States to publically commit to following its guidance.

2.3. Development of Guidance on the Import and Export of Radioactive Sources

In 2003–2004, the IAEA began efforts to improve the security of sources transferred across borders. The security of radioactive source imports and exports was of concern because these transactions were not being tracked and States were often unaware that large sources had entered their territories. Furthermore, there was minimal evaluation of whether a recipient was licensed to possess the sources and whether the receiving State had adequate controls. While the Code contained general export provisions, States requested specific guidelines so that these transactions were carried out in a harmonized fashion.

Like the revision of the Code, development of export control guidelines received considerable political backing. Leaders at the G8 Sea Island and the US–EU Shannon Summits endorsed the guidelines and announced their intention to put the guidelines in place by the end of 2005. At the 2004 G8 Summit at Sea Island, leaders announced:

> "We have agreed to export and import control guidance for high-risk radioactive sources, which should only be supplied to authorized end-users in states that can control them. ... We seek prompt IAEA approval of this guidance to ensure that effective controls are operational by the end of 2005 and applied in a harmonized and consistent manner. We support the IAEA's program for assistance to ensure that all countries can meet the new standards" [7].

In late 2004, the non-legally binding Guidance on the Import and Export of Radioactive Sources (Guidance) was approved by the IAEA Board of Governors and in 2005 it was published. The Guidance represents the first international framework for export control of radioactive sources and was an important step forward in preventing theft and diversion of materials being transferred across borders. It also evidences a shared commitment by exporting and importing States to the safety and security of radioactive sources, and has prompted ongoing and beneficial exchanges between States on the transfer of sources which are likely to have enhanced safety and security outcomes.

Similar to the Code, Member States included in the 2004 IAEA General Conference Resolution a call for States to make a political commitment regarding the Guidance. In Resolution GC(48)/RES/10, the General Conference:

> "endorses this Guidance while recognizing that it is not legally binding, notes that more than 30 countries have made clear their intention to work towards effective import and export controls by 31 December 2005, and encourages States to act in accordance with the Guidance on a harmonized basis and to notify the Director General of their intention to do so …" [8].

2.4. 2006 establishment of a triennial review mechanism

In 2006, the IAEA established a formalized process of information exchange between States in order to further facilitate implementation of the Code and the Guidance. This review mechanism was called for in the findings of the

2005 International Conference on the Safety and Security of Radioactive Sources, held in Bordeaux, France [9]. The information exchange process was carried out in 2007, 2010 and 2013, and the meetings were attended by 120 experts from 72 States in 2007 and 160 experts from 92 Member States in 2010 (in contrast, only 17 States attended the 2002 Code of Conduct meeting).

2.5. 2011 revision of the Guidance

In 2011, the IAEA convened consultants and experts meetings to consider what revisions may be necessary to strengthen the Guidance. The technical meeting was attended by 155 experts from 82 States. There was general consensus that the main provisions of the Guidance were effective and should not be altered, in part so as not to create any ambiguity about the status of States' political commitments to follow the Guidance. Participants did support revisions to update and clarify text in order to improve harmonized implementation. The biggest change was to annex 1, which provides a questionnaire for helping assess a State's ability to safely and securely manage imported sources. In September 2011, the IAEA Board of Governors approved the revised Guidance, which was published in 2012 [10]. Because no substantive changes were made to the main provisions of the Guidance, the Board and General Conference considered that States' political commitments to the IAEA Director General remained intact, unless the IAEA was notified otherwise by a State.

2.6. Other IAEA activities supportive of radioactive source safety and security efforts

The IAEA carries out a number of activities and offers a range of services that are supportive of efforts to improve controls for radioactive sources. These include the Integrated Regulatory Review Service (IRRS), the Integrated Nuclear Security Support Plan (INSSP), the Regulatory Authority Information System (RAIS) software for national source registry, workshops, training, and outreach, and the development of Nuclear Security Series guidance documents for radioactive sources and material, to complement the Safety Standards.

3. GOING FORWARD

3.1. Successes

The Code has been widely endorsed internationally. To date, 119 States have made a political commitment to work towards following the guidance in the

Code of Conduct, and 84 States have made an additional political commitment to act in accordance with the Guidance. In addition, in the Communiqué for the 2012 Nuclear Security Summit in Seoul, leaders urged States to:

> "reflect into national practices relevant IAEA Nuclear Security Series documents, the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and its supplementary document on the IAEA Guidance on the Import and Export of Radioactive Sources; and establish national registers of high-activity radioactive sources where required."

In another example, the Ministerial declaration of the July 2013 International Conference on Nuclear Security:

> "Invite[d] States that have not yet done so to make a political commitment to implement the non-legally-binding Code of Conduct on the Safety and Security of Radioactive Sources and supplementary Guidance on the Import and Export of Radioactive Sources, and encourage[d] all States to implement these instruments and to maintain effective security of radioactive sources throughout their life cycle" [11].

Further endorsement of the importance of the Code can be found in the President's Summary of that conference [12].

A second area of great success has been in regional cooperation. For example, from 2004 to 2013, the Australian Nuclear Science and Technology Organisation (ANSTO) ran a Regional Security of Radioactive Sources Project to help Australia's neighbours in South East Asia and the Pacific to develop or improve their capacity for security of radioactive sources and in radiation control to deal with poorly controlled, vulnerable or orphaned sources. The project worked in cooperation with Brunei Darussalam, Cambodia, Fiji, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Papua New Guinea, the Philippines, Singapore, Thailand and Viet Nam.

The project, run in close coordination with a similar project under the United States Global Threat Reduction Initiative, primarily aimed to improve the physical protection and security management of sources throughout their life cycle. Further, the project activities also involved capacity building for radiological emergency preparedness and response to enable cooperative partners to deal effectively and safely with any attempted, or actual, malicious act involving radioactive materials, should preventive measures fail, and situations involving radioactive sources out of regulatory control.

A third area of considerable success has been States' progress at the national level to implement the Code and improve life cycle controls for radioactive sources. This has been immensely assisted not only by regional cooperation and the robust bilateral assistance programs offered by a number of States, but also by the institution of the triennial information exchange process. The process[1], with meetings held in 2007, 2010 and 2013, has proven to be a key forum for the exchange of best practices by States. It is in some ways similar to the review process adopted under the Convention on Nuclear Safety and the Joint Convention, with states submitting National Reports which are then discussed in Country Groups, with common themes then being taken back to the Plenary for further discussion. The differences from the Convention process stem from the fact that the Code is a non-binding instrument. As a result, States are free to choose the level of their participation. Some States do not submit reports, but nevertheless attend, listen to other States' reports and learn from the discussions. Some States submit reports, but are uncomfortable discussing security issues in a public forum and therefore do not report on that aspect of the Code. Some States which have not made a national political commitment to the Code have nevertheless participated in the information exchange process.

The benefits of the information exchange process start from the writing of the report, which offers an opportunity for a rigorous self-assessment of each State's progress in implementation of the Code. Then the discussions at the meetings offer an opportunity to share experiences in the implementation of the Code's provisions. And it should not be thought that the process is a one-way process of developing States learning from developed States. Particularly in the area of security, it is has been seen that a number of developing countries have taken the lead, with some developed States only putting in place security regulation quite recently, and still wrestling with its practical implementation.

3.2. Challenges

Compared with the 1980s and 1990s, there now appear to be fewer serious accidents with detrimental health effects involving radioactive sources. In addition, to date there have not been significant malicious acts with wide ranging consequences involving radioactive sources. There seems to be little doubt that the Code and supporting work by the Agency and many States have contributed to improved controls over sources and a reduction in accidents. This work may well have also helped to reduce the likelihood of malicious acts. However,

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1 See http://www-ns.iaea.org/downloads/rw/code-conduct/info-exchange/formalized-process-english.pdf.

serious accidents, loss of control, and incidents involving theft or diversion have not been eliminated,[2] and the international community and national governments, regulators and users still have work to do in a number of areas.

3.2.1. Disused sources

Foremost of those issues yet to be fully addressed is the end-of-life management of sources. Quite apart from regulation, sources in use are protected by the user as an asset. In contrast, there is a temptation to discard disused sources. What can be done to ensure such sources remain under control and are safely and securely managed? What can be done to bring them back once out of regulatory control? This has been the subject of discussion at both the information exchange meetings and at two dedicated meetings under the Code [14, 15]. This issue is discussed in more detail elsewhere [16], but one aspect which is often overlooked is the importance of national waste management facilities. Even in States where national policy for management of disused sources is return to supplier, there needs to be an interim facility where sources can be safely and securely stored pending shipment.[3]

Another aspect of the problem of disused sources is the issue of orphan sources in scrap metal. Sometimes the source is detected before it is melted down. An example of that is an Australian instance, whereby in early 2012 a shipping container loaded with shredded scrap steel was intercepted at a foreign port by gate detectors. Local regulators identified the presence of ^{137}Cs. At great expense, a ship was chartered to divert its course to collect the container, which after transferring to another ship, was sent to Darwin and then on to Sydney by road. The owner sought assistance from ANSTO to recover the source of radiation and try to identify its origin. The source has been recovered and secured; work to identify its origin is ongoing.

Sometimes the source is not detected before it is melted down. Recently, the Australian regulator identified over 120 000 imported metal bowls, in two separate consignments, which had been contaminated with ^{60}Co. The bowls were of varying size, with activity varying according to size (~2–10 μSv/h).

[2] See Ref. [13] and http://www-ns.iaea.org/security/itdb.asp?s=4&l=28.

[3] This has been implicitly recognized by the IAEA General Conference (see operative para. 93 of Ref. [17] and operative para. 21 of Ref. [18]).

3.2.2. Implementation of the Guidance on the Import and Export of Radioactive Sources

The supplementary Guidance on the Import and Export of Radioactive Sources is a vital component of the regime covering safety and security of radioactive sources. Some might argue that it is the first widely accepted export control regime for radioactive sources. However, its efficacy depends upon its harmonized implementation, and it is important that the major exporting States continue to meet and discuss their export review practices to further harmonize implementation and create a level playing field for suppliers.

3.2.3. Security of sources

The Information Exchange meetings and the International Conference on Nuclear Security have demonstrated that progress in the implementation of security requirements has been positive but uneven — with many developed countries among the laggards. There is no doubt that regulators which have traditionally concerned themselves only with safety have to adopt a new mindset when considering security, and to interact with law enforcement and intelligence agencies with which they have traditionally not had a relationship. At the same time, national authorities need to be conscious that here, as in many areas of safety, a graded approach is desirable. In that context, one must consider whether it is really necessary to notify authorities around the globe of the loss of two Category 5 sources, as happened in 2013. Standardized reporting criteria may be desirable.

3.2.4. Liability issues

These issues are dealt with in some detail by another paper presented at the Conference.[4] Suffice to say that they fall into two categories:

(1) Firstly, contractual liability issues, including those surrounding contaminated scrap metal — the (lack of) responsibility to accept return of contaminated scrap and the lack of clarity around who bears the cost of such return.

[4] See L. Kueny, IAEA-CN-204/208, in Session 7, pp. 577–586.

(2) Secondly, third party liability. In many of the most serious cases, the State has had to bear the costs associated with treating injuries and cleaning up. In the case of the Goiânia accident in Brazil, the cost of remediation alone is estimated to have exceeded US $20 million. Given the general application of the 'polluter pays' principle, is this just? The international nuclear liability conventions obligate States Parties to require operators of nuclear installations (principally reactors) to hold large amounts of insurance, and hold them strictly and exclusively liable for all nuclear damage arising from a nuclear accident at their facility. Is it time for the holders of radioactive sources to face similar requirements?

4. CONCLUSION

Over the past ten years, the Code of Conduct and its supplementary Guidance have formed a foundation for significant improvements to the safety and security of radioactive sources internationally. Nonetheless, more work remains. One ongoing question has been whether the Code would be more effective if it were elevated to a legally binding convention. While some experts believe that incorporating the provisions of the Code into a legally binding instrument would raise the bar for radioactive source controls and the accountability of States, others believe the Code has been more effective and gained broader support as a non-legally binding instrument. One fear expressed is the impact that raising the Code to a convention would have on the status of the current 119 political commitments made by States to follow the Code. On the tenth anniversary of the Code, this question is still under consideration and in need of further discussion.

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REGIONAL OVERVIEW OF NATIONAL REPORTS ON IMPLEMENTATION OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES
Africa

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Abstract

According to the Code of Conduct on the Safety and Security of Radioactive Sources (Code) and Guidance on the Import and Export of Radioactive Sources (Guidance), African States prepared national reports and described the current status in States with regard to the implementation of the Code and the Guidance. From the African region that includes 52 States, 19 national reports were delivered (compared with 10 in 2010), 31 States expressed support for the Code (compared with 18 in 2010) and 25 expressed support for the Guidance (compared with 13 in 2010).

The information exchange process is voluntary, and it is recommended to describe the current circumstances in the country with regard to suggested topics. Only nine African States that sent reports followed the default structure and reported on all recommended topics of the Code, five States followed partially and five States did not follow the default structure.

1. THE INFRASTRUCTURE FOR REGULATORY CONTROL OF SAFETY AND SECURITY OF RADIOACTIVE SOURCES (PARAS 8 AND 18–22 OF THE CODE)

The legislative structures in the countries are not fully developed to include security in their legislative infrastructure. A number of States have newly established regulatory bodies and this is good progress since the 2010 reports. A diverse range of legislative infrastructures exist, with some being well established but some still being developed. Some States have just established their systems and are therefore still developing them. All of the States that submitted reports have legislation for regulating the safety and security of radioactive sources; however, many of them may not satisfy all the Code provisions. Some regulatory bodies are not sufficiently empowered for enforcement, nor appropriately resourced, nor effectively independent with regard to funding and decision making processes.

Many States use IAEA safety standards and the IAEA Nuclear Security Series to establish national regulations.

2. THE FACILITIES AND SERVICES AVAILABLE TO THE PERSONS AUTHORIZED TO MANAGE RADIOACTIVE SOURCES (PARA. 9 OF THE CODE)

All the States that sent in reports, except three, have personnel dosimetry services, while about half of the States have calibration facilities. Emergency response is mentioned in some of the reports and some of the regulatory bodies have staff assigned to this function. Some States have mentioned that an emergency response plan has been drawn up.

3. TRAINING OF STAFF IN THE REGULATORY BODY, LAW ENFORCEMENT AGENCIES AND EMERGENCY SERVICE ORGANIZATIONS (PARA. 10 OF THE CODE)

Capacity for training both frontline officers and regulators is limited, as only seven States have educational and training facilities. Examples of such training exercise are reported in most cases but with external support, such as the IAEA, and may therefore not be sustainable.

4. EXPERIENCE IN ESTABLISHING A NATIONAL REGISTER OF RADIOACTIVE SOURCES (PARA. 11 OF THE CODE)

All the States have national registers of radioactive sources for Category 1 and 2 sources, but some States still have challenges with either access to or using the Regulatory Authority Information System (RAIS), while one Member State uses ORACLE instead of RAIS. In most States, the national register includes all radioactive sources (Categories 1–5). Not a single State reports on the integration of the national register into a regulatory information system, for reporting and querying the processes of licensing, inspection and enforcement.

5. NATIONAL STRATEGIES FOR GAINING OR REGAINING CONTROL OVER ORPHAN SOURCES, INCLUDING ARRANGEMENTS FOR REPORTING LOSS OF CONTROL OVER RADIOACTIVE SOURCES AND FOR MONITORING ORPHAN SOURCES (PARAS 8(B), 12 AND 13 OF THE CODE)

Some of the African States have conducted search and secure projects with the assistance of external donors who provide instruments and training, while others have not done anything in this regard. Nine regulatory bodies have memoranda of understanding (MOU) with relevant government departments, which will formalize the procedure for detection and regaining control of radioactive sources. Sixteen of the reporting States have carried out search and secure training workshops and exercises. Five States report that they have installed portal monitors at nodal points (airports, seaports and metallurgical plants). Five States report activities in awareness campaigns to educate relevant governmental organizations and the public on orphan sources. No State reports any submission to the Illicit Trafficking Database (ITDB). National funding is a major challenge in carrying out these activities.

6. APPROACHES TO MANAGING SOURCES AT THE END OF THEIR LIFE CYCLES (PARAS 14 AND 15 OF THE CODE)

Many States do not have documented radioactive waste management policy and strategy, and long term management of sources remains a challenge. The prevalent radioactive waste management policy in all States is the ‘return to supplier’ (RTS) policy, but management of disused sources, legacy sources and orphan sources still remain a challenge to many States as only four States have facilities for radioactive waste management. There are, however, temporary storage facilities in others. None of the States (except one) has a disposal option for disused sealed radioactive sources.

7. EXPERIENCE WITH ARRANGEMENTS FOR IMPLEMENTING THE IMPORT AND EXPORT PROVISIONS OF THE CODE (PARAS 23–29 OF THE CODE) AND ITS SUPPLEMENTARY GUIDANCE

In the arrangements for the implementation of the import–export control of radioactive sources, the support of customs and other law enforcement agencies is crucial, 10 out of 19 of the regulatory bodies have MOU with the customs and/or the police. **Some regulatory bodies are not given prior notification by exporting countries in advance of shipment of Category 1 and 2 sources**.

8. ANY OTHER ISSUES RELEVANT TO THE IMPLEMENTATION OF THE CODE AND THE GUIDANCE

Some regulatory bodies in the reporting states are recently established and should be complimented on progress made in a short time. In general, the reporting on border monitoring, physical protection and other security issues tends to dominate some reports. Other Code of Conduct provisions are ignored. This may imply a focus on security to the detriment of safety. Some regulators are not properly authorized to carry out enforcement of their regulations.

9. MAIN PROGRESS AND ACHIEVEMENTS

There has been a significant increase in the number of States in the region that have indicated support for the Code and more States have shown willingness to share experience and lessons on the implementation of the Code. All States participate in the regional network of regulators (Forum of Nuclear Regulatory Bodies in Africa) and are willing to share experience on implementation of the code. Most States report nuclear security projects with international partners (e.g. Global Threat Reduction Initiative).

10. MAIN CHALLENGES

The IAEA should continue to strengthen the regional network to promote peer review so as to share solutions to common challenges, especially in the areas of safety and security of radioactive sources. A number of regulatory bodies has been recently established. Regulators are using the RAIS system to monitor regulatory activities. Some States have been detrimentally affected by political events, so progress in implementing their plans has been hampered. Some Member States still experience challenges in using RAIS and in drawing up MOU with the customs and other relevant law enforcement agencies, and most of the regulatory bodies still experience challenges with funding, staffing and training. The legislation in some Member States does not empower the regulatory body to carry out enforcement actions. The governance structure of some regulatory bodies makes it impossible for them to make independent judgment and decisions on matters affecting radiation safety.

11. FINDINGS OF REGIONAL MEETINGS

One regional meeting was held in Burkina Faso, in February 2012. The presentations at this meeting revealed many successes, but also widely varying outcomes and some problems in common, such as a lack of financial resources, a lack of experienced staff and limited resources for staff training. All findings including the suggestions for improvement and best practices are laid down in Chairman's reports (available on-line).

IAEA-CN-204/004

REGIONAL OVERVIEW OF NATIONAL REPORTS ON IMPLEMENTATION OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES
Asia

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Abstract

The paper aims to summarize the national reports on the experiences and lessons learned in implementing the Code of Conduct on the Safety and Security of Radioactive Sources (Code) and the Guidance on the Import and Export of Radioactive Sources (Guidance) submitted by States from the Asia region. The national reports briefly describe the current status in the country with regard to the topics described in the succeeding section. It will also discuss on main progress and achievements and main challenges or difficulties encountered over the last three years in the region.

This conference is very timely because it is the tenth year of implementation of the Code since it was approved by the IAEA Board of Governors on 8 September 2003. It will also host or will serve as the third open ended meeting of technical and legal experts to share information on States' implementation of the Code and its supplementary Guidance.

1. OVERVIEW OF THE REGION: BY THE NUMBERS

Figure 1 provides an overview of the region.

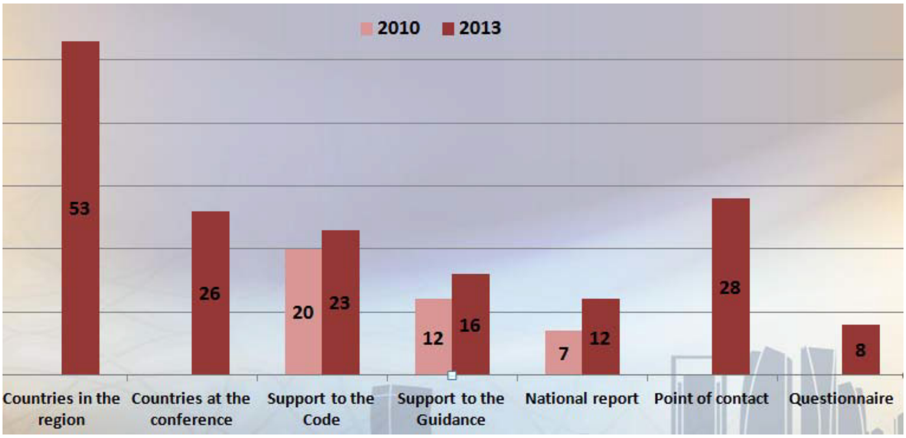

FIG. 1. State participation and response.

2. FORMAT OF NATIONAL REPORTS

Out of 23 States that signified their political commitment on compliance to the Code and Guidance from Asia region, only 12 States have submitted their national report. But it is nice to note that one State that has not yet committed to the Code has submitted a report. Of the 12 States that submitted the report only eight followed the instruction or guidance for the format and content (formalized process) of the report. In addition, 75% of the total number of States have addressed all the relevant issues or topics indicated in the instruction, knowing that per guidelines or instructions the author may choose among the topics but not limited to all the topics. Thus, following the instructions some States just stick to one or two topics but made it comprehensively (i.e. addressed the elements of the Code paragraph by paragraph). Furthermore, some States have cited their difficulties in establishing or maintaining the activities in compliance to the Code (e.g. sustenance of the expensive security gadget donated by a foreign project), likewise for success stories (i.e. maintenance of quality management systems certified to ISO 9001:2008). Others have mentioned some activities which not directly link to the Code but could have an impact, for example, the implementation of a management system which could put several processes of the Code into a formal or systematic structure.

3. CONTENT OF NATIONAL REPORTS PER COUNTRY ACCORDING TO THE ELEMENTS

3.1. The infrastructure for regulatory control of safety and security of radioactive sources (paras 8 and 18–22 of the Code)

Of 12 States that submitted the report, ten regulatory bodies (10/12) have indicated, or are well known, that they are 'independent', and the remaining two regulatory bodies noted that they have a pending bill or draft law being prepared or for enactment or approval of the legislative body. All States (12/12) have reported the existence of a regulatory system infrastructure for safety and security of radioactive sources in their country (i.e. with the publication of regulatory standard and guidance and the conduct of regulatory functions).

3.2. The facilities and services available to the persons authorized to manage radioactive sources (para. 9 of the Code):

All States (8/12) that responded to this topic indicated that facilities and services are available to the person authorized to manage radioactive sources, such as:

- Search and recovery of missing sources;
- Emergency preparedness centre;
- Personnel dosimetry;
- Calibration of radiation monitoring equipment (secondary standards dosimetry laboratory)
- Radioactive waste management facility (only three or four States).

3.3. Training of staff in the regulatory body, law enforcement agencies and emergency service organization (para. 10 of the Code)

All nine States (9/12) that addressed this topic indicated that they have existing training programme for the following:

- Regulatory staff;
- Security personnel;
- First responders;
- Emergency response team;
- National police and intelligence personnel;
- Customs and portal monitor operators, among others.

However, there are some apprehensions on its sustenance due to financial constraints.

3.4. Experience in establishing national registry of radioactive sources (para. 11 of the Code)

All States reported on establishing and maintaining a national register of Category 1 and 2 radioactive sources; 10/12 States report to have information also on Categories 3–5 in their national register. Five out of twelve States (5/12) have indicated that they are establishing or implementing the Regulatory Authority Information System web based version. The other States (7/12) are using their own designed system on national registry of radioactive sources. Among these States (7/12), one indicated that their system was designed in compliance to e-governance and one State has had their national register for three decades.

3.5. National strategies for gaining control over orphan sources, including arrangements for reporting loss of control over radioactive sources and for monitoring orphan sources (paras 8(b), 12 and 13 of the Code):

All ten States (10/12) that reported this topic have indicated that they have an established system and programme or national strategies for gaining or regaining control over orphan sources, including arrangements for reporting loss of control over radioactive sources and for monitoring orphan sources (e.g. nationwide search and monitoring project, portal monitors at customs area, and taking custody of the regained sources, among others). Two States (2/12) did not report on this topic.

3.6. Approaches to managing sources at the end of their life cycles (paras 14 and 15 of the Code)

Although one or two States stated a ‘cradle to grave’ approach, most States (11/12) indicated the return of disused radioactive source to its country of origin. In one State, one of the highlights of the report was the conditioning of the disused teletherapy sources using the spent high activity radioactive sources (SHARS) portable hot cell through the financial support of the IAEA. The developed countries in the region have planned long term management of disused sources, while for developing countries, it is still a regulatory concern, since the return of disused radioactive source to its country of origin seems to have some financial constraints.

3.7. Experience with arrangements for implementing the import and export provisions of the Code (paras 23–29 of the Code) and its supplementary Guidance

Three States (3/12) did not respond or report this topic. The other nine States (9/12) indicated that they have a system for implementing the import and export provisions of the Guidance (i.e. receiving radioactive source is to have prior authorization from the regulatory body).

3.8. Any other issues relevant to the implementation of the Code and Guidance, with a special emphasis on the progress made and challenges met over the last three years

(a) Successful recovery and recycle and/or conditioning and disposal of disused radioactive sources.
(b) There is a nuclear security training centre equipped with state of the art laboratories in the region.
(c) The problem on border monitoring (i.e. lack of comprehensive monitoring capabilities throughout the land, air and sea ports) to control the entry of radioactive sources and materials, especially in the States in the region with many islands.
(d) The world's first radiation source location tracking system developed and operated for the safety and security of radioactive sources and emergency response during accidents.
(e) The regulatory compliance on technical requirements on the maintenance and sustenance of programmes and projects initiated through foreign funds (e.g. for detection and deter illegal transportation of radioactive and nuclear materials and portal monitors) and teletherapy ^{60}Co facility security systems.

4. MAIN PROGRESS AND CHALLENGES

The contents of this section are the main progress and challenges in the region as reflected in the national report:

(a) Main progress:
   (i) There are several upgrades under the bilateral cooperation/international initiatives were implemented at most Category 1 facilities.

- (ii) The full implementation of the regulatory framework for an integrated safety and security of radioactive sources, particularly by establishing an inspection programme on security requirements with assurance that the licensees continue to effectively implement clearly established protection and safety programmes.
- (iii) There are training programmes for regulatory body staff and other relevant agencies that were highlighted and emphasized in many national reports and acknowledges the importance of IAEA programmes and those offered by other international and donor organizations.
- (iv) More reports submitted now than the past two open ended meetings, in 2007 and 2010. There are fewer concerns and issues and more achievements reflected in the reports now.

(b) Main challenges:

- (i) Sustaining the operation and maintenance of radiation detection equipment and security gadgets are big challenges after the expiry of warranty period.
- (ii) The provision of guidance on appropriate levels of information, instruction and training on activities pertinent to the safety and security of radioactive sources (i.e. structured training programme for regulatory staff and other relevant agency staff). Moreover, the sustenance of trainings for other agencies with constant changes in personnel assigned (e.g. police officers).
- (iii) The main challenge to States for long term management of disused radioactive sources is tied directly with the associated costs. Since the cost of returning sources to the supplier State remains prohibitive, some States have opted to store sources at their interim radioactive waste management facilities.

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REGIONAL OVERVIEW OF NATIONAL REPORTS ON IMPLEMENTATION OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES
Europe

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Abstract

According to the Code of Conduct on the Safety and Security of Radioactive Sources (Code) and Guidance on the Import and Export of Radioactive Sources (Guidance), European region States prepared national reports and described the current status in States with regard to the implementation of the Code and Guidance. From the European region, which includes 53 States, 27 national reports (compared with 10 in 2010) were delivered, 46 States expressed support for the Code (compared with 45 in 2010) and 28 for the Guidance (compared with 21 in 2010).

The information exchange process is voluntary, and it is recommended to describe the current circumstances in the State with regard to suggested topics. Seven European region States followed the default structure and reported on all recommended topics of Code, some States followed partially (12 from 27), eight States did not follow it. It is observed that the following topics and supplementary Guidance are often missing: facilities and services available to the persons authorized to manage radioactive sources (para. 9 of the Code); training of staff in the regulatory body, law enforcement agencies and emergency service organizations (para. 10 of the Code); approaches to managing sources at the end of their life cycles (paras 14 and 15 of the Code); and experience with arrangements for implementing the import and export provisions of the Code (paras 23–29 of the Code).

A good practice example is one State that used self-assessment according to the IAEA questionnaire and produced a complete report. In addition, 19 European region States identified the progress and successes, challenges, areas for improvement in their national reports. Security of radioactive sources, information for the public and stakeholders, emergency preparedness are the most often reported parts as the other relevant issues.

1. THE INFRASTRUCTURE FOR REGULATORY CONTROL OF SAFETY AND SECURITY OF RADIOACTIVE SOURCES (PARAS 8 AND 18–22 OF THE CODE)

Practically all European region States (26/27) reported that infrastructure for regulatory control of safety and security of radioactive sources is fully implemented, in particular regarding the enforcement of requirements. European region States have a legislative framework, in EU Member State legislation is done according EU directives and EU Basic Safety Standards, safety standards and nuclear security series. Twenty-two States reported new regulations and amendments implemented during the reported period (from 2010). Nine States reported on the integration of safety and security in national regulatory infrastructure. For two States with several regulatory bodies, reports are on the activities of the only regulatory body, thus it is difficult to consider these reports as national. Peer reviews and advisory missions are reported as effective means to ensure compliance with the Code place.

2. THE FACILITIES AND SERVICES AVAILABLE TO THE PERSONS AUTHORIZED TO MANAGE RADIOACTIVE SOURCES (PARA. 9 OF THE CODE)

Fourteen (from 27) European region States reported having appropriate technical services and facilities provided by executive authorities. However, 13 States did not mention about this topic in national reports at all.

3. TRAINING OF STAFF IN THE REGULATORY BODY, LAW ENFORCEMENT AGENCIES AND EMERGENCY SERVICE ORGANIZATIONS (PARA. 10 OF THE CODE)

Thirteen (from 27) European region States reported having implemented training programmes for staff and other relevant government agencies (customs, law enforcement officers and emergency response agencies). Three other States reported that they did not have sustainable national training system and relied on IAEA training programmes and bilateral undertakings (3/27). One State reported that in the past, the regulatory body mainly relied on international assistance, but now a national training centre for the safety and security is under commissioning. Eleven European region States did not even provide information on this topic.

4. EXPERIENCE IN ESTABLISHING A NATIONAL REGISTER OF RADIOACTIVE SOURCES (PARA. 11 OF THE CODE)

All European region States reported a national register of Category 1 and 2 radioactive sources. In most States (24/27), the national register includes Category 1–5 radioactive sources. In some States, the national register is part of regulatory information system that includes licensing, inspection, dose register, among other things, and interacts with this subsystem. Four States use a national register that is based on the Regulatory Authority Information System. A good practice example is a national register that keeps interaction with licensees and involved authorities.

5. NATIONAL STRATEGIES FOR GAINING OR REGAINING CONTROL OVER ORPHAN SOURCES, INCLUDING ARRANGEMENTS FOR REPORTING LOSS OF CONTROL OVER RADIOACTIVE SOURCES AND FOR MONITORING ORPHAN SOURCES (PARAS 8(B), 12 AND 13 OF THE CODE)

Most European region States reported implementation of all or some elements of a national strategy. Twenty-five States have implemented procedure of regaining control over orphan sources (sometimes in the form of memoranda of understanding with relevant governmental departments for detection and regaining control of radioactive sources). Twenty-four States reported a system of reporting for the loss of control over radioactive sources. Administrative search and passive search (portal monitors at nodal points — i.e. border crossings, ports, scrap yards, landfills, metallurgical plants) are implemented in 16 European region States. Seven States reported outreach campaigns to educate relevant governmental organizations and the public on orphan sources. Thirteen States implemented active searches and campaigns for the collection of vulnerable radioactive sources from bankrupt or financially unstable enterprises, physical persons (big summary activities, safe and secure storage provided). Eight States reported problems with the recovery of radioactive sources at the borders. Two European region States did not provide information on this topic.

6. APPROACHES TO MANAGING SOURCES AT THE END OF THEIR LIFE CYCLES (PARAS 14 AND 15 OF THE CODE)

Some States (17/27) have effectively implemented financial guarantees for long term management of radioactive sources as return abroad or long term storage. However, other States continue to rely solely on the option of future return to the supplier abroad without financial guarantees. One State reported the recycling at national facilities and reuse as national practice. In addition, ten European region States did not provide any information about their experience and practices in managing radioactive sources at the end of their life cycles.

A good practice example was IAEA Technical Cooperation Project INT/9/176, Strengthening Cradle to Grave Control of Radioactive Sources in the Mediterranean Region. Under this project, participants receive support and advice on drafting policies and strategies on the control of radioactive sources to ensure that they are properly regulated at all times, from the production, trade, use, recycling/reuse, repatriation, processing when disused, transportation, storage and disposal. The project also addresses the need for national policies and strategies for the management of orphan sources.

7. EXPERIENCE WITH ARRANGEMENTS FOR IMPLEMENTING THE IMPORT AND EXPORT PROVISIONS OF THE CODE (PARAS 23–29 OF THE CODE) AND ITS SUPPLEMENTARY GUIDANCE

Most States (23/27) reported that the compliance with guidance requirements and authorization of imports and exports is effective instruments. Three States reported planning to (Administrative Arrangement within the Eurasian Economic Community) or establishing multilateral and bilateral arrangements in different forms to harmonize procedures related to the import and export of radioactive sources.

8. ANY OTHER ISSUES RELEVANT TO THE IMPLEMENTATION OF THE CODE AND THE GUIDANCE

European region States reported on the following issues:

- International cooperation;
- Environmental monitoring;
- Safety and security integration;

- — Information for the public and stakeholders;
- — Facilities with radioactive sources physical protection upgrades;
- — Emergency preparedness issues.

8.1. Main progress and achievements

European region States reported on the progress that was made in improving security of radioactive sources especially in facilities physical protection. It was also reported that passive physical search in nodal points, including controlling scrap metals, has been established; active search is under the implementation in some States. It shows the progress in regaining control of the orphan radioactive sources. Multilateral cooperation to combat illicit trafficking and regaining control over radioactive sources between neighbouring States is improving through formalized, specific agreements. More States reported that the agreements between regulatory authorities and law enforcement authorities have already established (e.g. custom services and security service). States reported that detailed information was provided to the public and stakeholders on what to do in case unknown objects (that can be orphan sources) are found and how to report. European region States reported that collection campaigns for orphan sources and radioactive at the end of their lifetime are performed, many radioactive sources are consolidated at the national facilities, where safe and secure storage is provided.

8.2. Main challenges

The main reported challenges are related to the implementation new European Commission safety requirements. There is no predefined and clear national policy and strategy for the up to end management of the radioactive disused sources and material, so many European region States need to define clear strategy for the management of disused sources and radioactive material with final solution (such as disposal). European region States also need to continue put sufficient resources into identification, collection and safe and secure management of disused and orphan sealed sources. The global market of scrap metals and radioactive sources and a control of scrap metals are challenging issues for European region States.

8.3. Findings of regional meetings

Two regional meetings (in Vilnius, Lithuania, and Tirana, Albania) for sharing experience and lessons learned in implementing the Code and Guidance were held in 2013. The purpose of the meetings was to obtain an overview of the current status of participating States national infrastructures for safety and security in the context of the Code and its supplementary Guidance, and to provide a platform for exchanging experience, lessons learned, successes and challenges. All findings, including the suggestions for improvement and best practices, are laid down in the Chairman's reports (available on-line).

REGIONAL OVERVIEW OF NATIONAL REPORTS ON IMPLEMENTATION OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES
Americas

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Abstract

According to the Code of Conduct on the Safety and Security of Radioactive Sources (the Code) and Guidance on the Import and Export of Radioactive Sources (the Guidance), Americas region States prepared the national reports, described the current status in States with regard to the implementation of the Code and Guidance. From the Americas region, which includes 35 States, 9 national reports were delivered (compared with 8 in 2010). Nineteen States expressed support for the Code (compared with 16 in 2010) and 15 to the Guidance (compared with 10 in 2010). Twenty-two States have designated at least a point of contact. Fourteen States have sent questionnaires and 15 represented in the conference.

The information exchange process is voluntary and it is recommended to describe the current circumstances in the State with regard to suggested topics. Three Americas region States followed the default structure and four reported on all recommended topics of Code, some States followed partially, and others did not follow it. It is observed that the following topics are often missing: facilities and services available to persons authorized to manage radioactive sources (para. 9 of the Code); and national strategies for gaining or regaining control over orphan sources.

One State submitted its national report even though it has not expressed support of the code. All national reports in the Americas region identify progress, successes, challenges or areas for improvement in their national reports. Security of radioactive sources, information for the public and stakeholders, emergency preparedness are the most often reported parts as the other relevant issues.

1. THE INFRASTRUCTURE FOR REGULATORY CONTROL OF SAFETY AND SECURITY OF RADIOACTIVE SOURCES (PARAS 8 AND 18–22 OF THE CODE)

All States in the Americas region which submitted a national report have addressed this topic. All have in place a legal framework, through legislation and regulations that meet the provisions of the Code of Conduct, and assigning responsibilities to one or several national competent authorities regarding the control of radioactive sealed sources. Information indicates that regulatory oversight of radioactive sources is carried out throughout the life cycle of the sources (i.e. from cradle to grave). In general, the onus of safety relies upon the users or licensees of radioactive sources. However, regulatory controls are in place to prevent incidents, accidents and a loss of radioactive sources. States are committed to the Code of Conduct, but not all have committed to the Guidance. It is not certain that all have established independent regulatory bodies. Regulatory authority regarding sealed sources may be within a single regulatory body, while in some States the authority is split between two or more regulatory bodies or other types of government entity (e.g. ministry of health). Two regulatory bodies may have the same role to play, but applied to different nuclear sectors (e.g. medical vs non-medical). Some States (2/9) have regulatory bodies that may have responsibilities to regulate radioactive sealed sources as well as X ray equipment. It is interesting to see that some States (3/9) have established e-business systems which make it more efficient for applicants and licensees to conduct business with the regulatory bodies.

2. THE FACILITIES AND SERVICES AVAILABLE TO THE PERSONS AUTHORIZED TO MANAGE RADIOACTIVE SOURCES (PARA. 9 OF THE CODE)

All States in the Americas region which submitted a national report have addressed this topic, but for some States this was not covered to the full extent of the topic. In some reports, the information is not provided under the specific topic section but addressed elsewhere in the report. The information indicates that facilities, equipment and services (e.g. laboratories, service providers and instrumentation) exist regarding dosimetry, environmental monitoring, detection and measurement, instrument calibration, management of disused and orphan sources, and emergency intervention regarding radioactive sources. Although licensees and other regulated persons are responsible for the safe use of radioactive sources, the regulatory bodies offer assistance (regulatory advice and technical assistance) where needed. Some States have elaborated national strategies and programmes for effective emergency intervention and management of events involving lost or orphan radioactive sources, with proper equipment, training and facilities available to deal with these situations. In some States (5/9), equipment is installed at scrap metal facilities to detect and deal with radioactive material found in scrap or recycled goods. Similar equipment is also installed at national borders or customs facilities to detect entry of radioactive material. Facilities exist in some States (6/9) for treatment, storage, disposal or long term management of disused and orphan sources. Programmes and protocols are in place to facilitate the transfer of disused or orphan sources within the State or to other recipient States.

3. TRAINING OF STAFF IN THE REGULATORY BODY, LAW ENFORCEMENT AGENCIES AND EMERGENCY SERVICE ORGANIZATIONS (PARA. 10 OF THE CODE)

All States in the Americas region which submitted a national report have addressed this topic, but for some States this was not covered to the full extent of the topic. Some States (2/9) have programmes in place to certify occupational workers who handle radioactive sources in order to ensure that they have the right knowledge, expertise and training to safely carry out their work. In some States (5/9), postgraduate courses and other training resources and facilities are available to staff in the regulatory bodies, law enforcement agencies and first responders to gain knowledge in the use of radioactive sources and radiation safety so as to effectively carry out their duties and responsibilities. It is important to have a sufficient number of qualified and trained personnel to ensure safety and security of radioactive sources. Some regulatory bodies indicate they employ a high number of personnel with postgraduate university degrees. It has been pointed out for some States (2/9) that retention of young personnel within the regulatory body may be a challenge because of working conditions being not so attractive.

4. EXPERIENCE IN ESTABLISHING A NATIONAL REGISTER OF RADIOACTIVE SOURCES (PARA. 11 OF THE CODE)

Not all States in the Americas region which submitted a national report have addressed this topic. The establishment of national registers has proven to be an effective means to control the ownership, possession, location and movement of radioactive sealed sources within the State, in some cases from the manufacturing to final disposal. However, information on the source movement is no longer available when the source is exported outside the State. In some States, other regulatory bodies beside the main nuclear regulator may have their own inventory of sources. Various national databases in electronic format, or other format, consigning the inventory of radioactive sources in the State are in place. Some States (2/9) have adopted the IAEA Regulatory Authority Information System to establish their national register, or have received help from other States to set up their register. Some registers are integrated into the regulatory body's licensing and compliance verification systems which makes it more effective. Information from compliance inspections helps to update the register. Not all States (4/9) have information on Category 1–5 sources in their register. Most information concerns Category 1 and 2 sources only. Some States have established secure web based tracking and reporting systems for providing information to include in the national registry, and again not for all source categories. Some States have established requirements for licensees to mandatory track and report transfers of high risk sources (Categories 1 and 2). It is reported that systems maintenance and updates of national registers represent a challenge. In addition, exchange of information from one State to another with respect to imported or exported sources is a challenge due to incompatibility of systems or the protected nature of information.

5. NATIONAL STRATEGIES FOR GAINING OR REGAINING CONTROL OVER ORPHAN SOURCES, INCLUDING ARRANGEMENTS FOR REPORTING LOSS OF CONTROL OVER RADIOACTIVE SOURCES AND FOR MONITORING ORPHAN SOURCES (PARAS 8(B), 12 AND 13 OF THE CODE)

Not all States in the Americas region which submitted a national report have addressed this topic, and for some of these States this was not covered to the full extent of the topic. In general, all these States have put emphasis in handling radiological emergencies (through appropriate, available organizations) and in some of the following issues.

Some States (3/9) have made agreements between different organizations that could be involved in order to fluidize communication and to train different actors (including licensees) as part of the strategy to avoid loss of control over radioactive sources (in domestic forums and international ones).

One State has trained the population, which were informed how to respond to the robbery of radioactive material.

Some States (4/9) are developing and distributing information in order to increase communication and awareness with the metal recycling industry and conventional waste facilities, especially for radiation portal monitor users, focusing on identifying and managing orphan sources, or giving support to industries that work with scrap metal in the installation of monitoring systems to reduce the risk of radioactive scrap metal production.

Some States (2/9) are collecting the disused sources throughout the country to reduce the radiological risk, in different manners (through programmes and manufacturers among others).

One State is studying:

— The establishment of financial guarantees for licensees to cover costs associated with the remediation of a location as a result of the termination of licensee operations and the safe disposal of any radioactive sealed sources left behind;
— The incorporation of orphan sources in outreach programmes to the licensed community across the State;
— The development of an infrastructure to identify owners of sources that have been identified as orphaned sources;
— The presence of internal procedures to ensure that regulatory authority staff are aware and familiar with the actions to be taken following the discovery of an orphan source.

One State remarked the importance it gives to taking part in international forum focused on the preparation of a strategy for the prevention, detection and response to the inadvertent presence of radioactive material in the recycling of metals and other associated processes.

In one State, regulations stipulate reporting requirements that each licensee needs to follow for any lost, stolen, or missing licensed material — not only for Category 1 and 2 radioactive sources but also others.

One State expressed having a recovery of orphan sources system was a challenge.

6. APPROACHES TO MANAGING SOURCES AT THE END OF THEIR LIFE CYCLES (PARAS 14 AND 15 OF THE CODE)

Not all States in the Americas region which submitted a national report have addressed this topic. Some States (2/9) have in place requirements that oblige the return of sources to the providers outside the State. Nevertheless, no comment is provided about a strategy for its management in case of failure to return the source at the end of its life. Some States (5/9) have available techniques and facilities in place to recycle sealed sources at the end of their useful life by either reusing decayed sources, re-encapsulating them or reprocessing them for other uses. Not all States have available waste management facilities. One State grants licenses only for possessing the sealed sources that can be transferred at the end of their life. One State reports to have in place regulations on exemption quantities and clearance levels in order to classify sealed sources at the end of their life and leave them outside the regulatory control. It is not clear in some cases whether the State has waste management facilities or capability for recycling.

One State expressed to have, in the medium term, a site for the safe management of radioactive waste.

One State expressed the availability of two more sites opened for the disposal of sources, nevertheless recognizing that some Category 1 and 2 sources are still excluded from current disposal options due to the State's waste classification system.

7. EXPERIENCE WITH ARRANGEMENTS FOR IMPLEMENTING THE IMPORT AND EXPORT PROVISIONS OF THE CODE (PARAS 23–29 OF THE CODE) AND ITS SUPPLEMENTARY GUIDANCE

Not all States (7/9) in the Americas region which submitted a national report have addressed this topic, and for some States this was not covered to the full extent of the topic. And in general, States show different degrees of compliance with the Code and the Guidance. Some States mention importing procedures, others also records, but it is not clear whether Code and Guidance provisions are covered, as well whether in this last case the transportation of radioactive sources is done according to international standards. Some States express the efforts done in order to work in a harmonized way between regulatory body and customs, sharing information through electronic systems, in some cases through which they both are directly connected. Few States have expressed they have an import and export control programme for Category 1 and 2 sources consistent with the Code and the Guidance that encompasses licensing, compliance, prior shipment notifications to importing States, State to State requests for import consent of Category 1 sources and the establishment of bilateral administrative arrangement. In the case of one State, it includes post-shipment verifications.

Two States are negotiating the confirmation of receipt of radioactive sources, in the case of one of them through several bilateral administrative arrangements.

National reports, in general, indicate an increase in administrative arrangements or memoranda of understanding between States on this issue: some in place, others pending.

One State has expressed the alignment with the Code and Guidance was achieved after a process that included government agencies and also the public.

8. ANY OTHER ISSUES RELEVANT TO THE IMPLEMENTATION OF THE CODE AND THE GUIDANCE

One State has established a complete information technology system that allows electronic communication between licensees and the regulator, with information on the licensees and their authorizations, sources, calibration certificates and compliance with the requirements, among other things. A challenge for the future is the development of a new database to improve the control process for radioactive sources.

One State has given great importance to making agreements with different parties: IAEA and other States with different objectives related to the Code of Conduct.

One State hosted the IAEA Integrated Regulatory Review Service mission in 2011, which identified its source tracking and national registry as a good practice to strengthen the regulatory programmes for radioactive sealed sources and radiation devices.

One State has worked to improve communication with the public by publishing information on safety and performance of nuclear substances, information on national sealed source registry and sealed source tracking system, information on lost or stolen sealed sources and radiation devices through annual reports.

Two States are pursuing discussions regarding the feasibility of an electronic exchange of sealed source information to achieve complete source tracking from one country to the other. They have successfully conducted data exchange testing.

One State amended its regulations on authorizations, taking into account the recommendations of the Code and the Guidance.

The regulatory bodies in one State have conducted several national courses and workshops in relation to the State's national plan of radiological emergency and for the occupationally exposed workers, in coordination with another State.

One State has not developed yet a final solution for the financial arrangements in the case of bankruptcy, although the regulator has the role to act in case of it charging costs on the shoulders of the State, which is a pending matter.

One State is planning in the medium term to have educational programmes to promote safety culture.

Two States have made upgrades to their standards, especially in security.

In November 2009, licensing staff met with two Asian regulators to share information covering: licensing requirements, Code of Conduct implementation, enforcement, licensing statistics, and interface with CBP. In July and August 2010, licensing staff had similar import/export information exchanges with regulatory counterparts in two other States.

8.1. Main progress and achievements since 2010

As reported by States which have submitted a national report, national regulatory frameworks, from legislation and regulations, have evolved over the last ten years to align with the provisions of the Code and Guidance. Effective control of radioactive sealed sources by national competent authorities which established licensing and compliance programmes, source registers and adequate facilities within their States ensure the safety and security of sealed sources. Some source registers have a secure web based interface, which makes it practical and user friendly for users. Some registers are integrated in the national regulatory programmes of licensing and compliance, which makes it more efficient for the regulator to provide effective regulatory oversight of radioactive sources.

8.2. Main challenges in the region

Although effective regulatory systems are in place in the States which committed to the Code of Conduct, not all of them have committed to the Guidance. Not all States have facilities and equipment for the detection of sources in scrap or recycled material within the country or entering the country. Tracking and registering sources that are imported or exported is a challenge since there are difficulties in exchanging source register information between States or obtaining prior consent.

Some States will initiate revision of the standards to incorporate the new recommendations of the basic standards of the IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [1].

One State reported the challenges in developing information web pages to provide information on regulatory requirements and guidance, with respect to the code and radioactive source safety and security, implement an administrative monetary penalties system that will give the regulator an additional enforcement tool to ensure compliance with its regulatory requirements. Improvements to the State's national sealed source registry and sealed source tracking system have been made in relation to sources that have decayed below their exemption quantity.

One State is promoting a multilateral administrative arrangement in the framework of the Mercosur for imports and exports.

One State is reviewing the Guidance 2012 edition in order to present:

- A political commitment to the IAEA;
- Revision and completion of the self-assessment questionnaire;
- Assessment of the IAEA sources categorization in order to adopt it;
- A memorandum of understanding with relevant suppliers, which is being contemplated.

One State has a big challenge that is to solve the independence in the decision making because of the existence of two regulatory bodies, and the lack of coordination, in relation to medical applications.

One State achieved Member State status with the IAEA in November 2012 and is engaged in significant effort towards full implementation of the Code of Conduct. This includes work to update the State's regulatory framework, with clearer legislation and regulation, clearer functions and authorities for the independent regulatory body, and establishment of suitable infrastructure for safe management of radioactive waste.

8.3. Findings of regional meetings

Only one regional meeting (Chile) for sharing experience and lessons learned in implementing the Code and Guidance was held in 2010. The purpose of the meetings were to obtain an overview of the current status of participating States' national infrastructures for safety and security in the context of the Code and its supplementary Guidance, and to provide a platform for exchanging experience, lessons learned, successes and challenges. All findings including the suggestions for improvement and best practices are laid down in Chairman's reports (available on-line).

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MANAGEMENT OF HIGH ACTIVITY SEALED SOURCES IN THE EUROPEAN UNION

HASS Directive implementation status and legal developments

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Abstract

European Union Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS Directive) requires EU Member States to put in place several measures in order to guarantee the safety and security of high activity sealed radioactive sources (HASS) and to search for orphan sources. These legally binding measures are in line with the requirements of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources. The paper discusses the results of the recent HASS Directive implementation review and the results of a supporting study project under the EU action plan on chemical, biological, radiological and nuclear security. The paper also outlines the current development of the HASS legislation in the European Union, especially in terms of the proposed new EU Basic Safety Standards Directive.

1. INTRODUCTION

Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS Directive) [1] entered into force on 31 December 2003, and its legal enactment period ended two years later. Each EU Member State has designated a competent authority to carry out tasks in accordance with the Directive [2]. Article 14 of the Directive requires EU Member States to report on their implementation before the end of 2010. The Commission is then required to provide an implementation report of the Directive to the European Parliament and the European Economic and Social Committee. This type of review mechanism is not commonly laid down in EU legislation, and many EU Member States remarked that the Commission should have provided more guidance on the content of the national implementation report. The reporting process provided input also for the drafting of the new EU Basic Safety Standards (BSS), although the main work on the new BSS text took place before all national HASS reports were available.

The implementation review was carried out by analysing the individual reports submitted by EU Member States. All EU Member States have enacted the HASS Directive in their national legislation, but the review results indicate variable practices in the practical implementation of the Directive requirements. This is not surprising, since the number of high activity sealed radioactive sources (HASS) sources in EU Member States range from only a few to several thousands. The quality of the reporting was also highly variable, illustrating the fact that some States have very advanced HASS control arrangements and administration, whereas some States seem to have paid little attention to HASS safety and security.

The supporting study project — Study on the current status of radioactive sources in the EU, on the origin and the consequences of the loss of control over radioactive sources and on successful strategies concerning the detection and recovery of orphan sources — was initiated by the European Commission in order to provide an overview of the situation in the European Union on:

(a) The control of high activity sources in use;
(b) The management of disused sources;
(c) Strategies for handling orphan sources.

The project was part of the EU CBRN Action Plan [3]. It is based on questionnaires, interviews and fact finding missions among the European stakeholders. The study identifies best practices and possible weaknesses in the detection and recovery of orphan sources and provides an overview of incidents of loss of control in Europe.

2. HASS DIRECTIVE IMPLEMENTATION REVIEW

2.1. HASS inventory in Europe

According to the data reported by 25 EU Member States, the European inventory of HASS comprises about 30 700 HASS, of which 50% is represented by only Germany and France. Nine EU Member States have an inventory of fewer than 100 HASS. About 3200 HASS holders are recorded in 24 EU Member States, of which 63% is represented by Germany, France, Poland and the United Kingdom. Typically, there are 1–40 individual HASS per holder (in some cases multiple source devices are counted as one source).

2.2. Implementation overview

Figure 1 presents on overview of the HASS Directive implementation status in the 27 EU Member States. Results are presented as **implemented** (OK), **require attention** (PoA) and **not implemented** (NOK). As can be deduced from the graph analysis, there is, in general, good compliance with the implementation of the HASS Directive requirements.

Note: OK — implemented; PoA — point of attention (require attention); NOK — non-compliance (not implemented).

FIG. 1. Overview of HASS Directive implementation in the 27 EU Member States.

2.3. Points for attention on implementation

Although, in general, compliant with the requirements of the HASS Directive, five subjects frequently show points requiring attention:

(1) The points for attention related to the legislative framework that are observed in 12 EU Member States are the following:
- Different activity levels than those set in the HASS Directive are considered to define HASS (i.e. Category 3 levels).
- The report sent to the EC on the experience gained in the implementation of the HASS Directive is limited.
- The implementation of the definition of HASS in the national regulation is not compliant with the Directive. Indeed, several EU Member States which use the same HASS definition as that given in the HASS Directive consider in practice the actual activity levels of the source when implementing the national provisions. As such, a source whose activity has fallen below the high activity levels of the Directive will be covered by the requirements for non-HASS.

(2) The main points for attention linked to the control of HASS by the holder are the following:
- No systematic leak tests of the HASS are performed by the HASS holders.
- The test programme carried out by the source holders is limited (only visual verification, no dose rate measurements or leak tests).

(3) In ten EU Member States, the documentation accompanying the HASS is not fully compliant with the requirements of the Article 7 of the Directive, which requests that the manufacturer provide a photograph of each manufactured source design type and of the typical source container. The holder is to ensure that each source is accompanied by written information, including photographs of the source, source container, transport packaging, device and equipment, as appropriate. Moreover, historical sources without an ID number are also present in some EU Member States.

(4) The main point of attention regarding the long term management of HASS concerns the allowed period for storing disused HASS at the holder's premises. The HASS Directive pleads for a transfer of each disused source without undue delay after it goes out of service. However, several EU Member States do not define in their regulatory regime the maximal period for storing disused sources at the holder's premises, after which transfer becomes mandatory. In several EU Member States, the financial guarantee for the safe long term management of disused sources is uncertain. Finally, it seems that HASS holders are not obliged to make

adequate arrangements for the long term management of disused HASS during the licensing process in one EU Member State, although it is required by Article 3.2 (b) of the HASS Directive.

(5) The last subject requiring attention is the training and the information of workers potentially confronted with orphan sources. In four EU Member States, such training is not organized; while in eight other EU Member States, this training is either not required by regulation, or not given to all types of workers, or not carried out in all facilities at risk, or neither documented nor repeated.

2.4. Cases of a possible lack of implementation

Only one requirement is poorly implemented in about half of EU Member States: the organization of orphan sources recovery campaigns. Indeed, Article 9.4 of the HASS Directive requests that EU Member States ensure that campaigns are organized, as appropriate, to recover orphan sources left behind from past activities. The interpretation of the project team with respect to this requirement is that EU Member States are obliged to organize such recovery campaigns. Therefore, the evaluation was determined as non-compliant for the 14 EU Member States where no orphan sources recovery campaign has been organized. However, several arguments were forwarded by the EU Member State to justify why such recovery campaigns are not organized. These main arguments are:

— HASS are under control and cannot become orphan sources.
— The inventory of HASS is complete and up to date.
— Detection means are installed at borders of the country.
— No orphan sources have been discovered yet.
— No recognized storage facility is available for the storage of recovered orphan sources.
— Recovery campaigns were organized before the HASS Directive was enacted.

In three EU Member States, the requirements concerning record keeping (Article 5) are also incorrectly implemented because the direct notification of modifications of the status of HASS to the authority is not ensured.

2.5. Recommendations for improved implementation

Based on the analysis of the HASS Directive enactment, several suggestions can be addressed to the EU Member State in order to improve its implementation:

(1) The need for organizing systematic or dedicated orphan sources recovery campaigns should be assessed in those EU Member States which have not yet organized such campaigns. A first step towards assessing the need of a recovery campaign would be the analysis of historical records available at the authority and at the manufacturers/suppliers. During inspections at facilities where disused sources are more likely to be found (i.e. hospitals, universities, research centres, military sites, etc.) more thorough investigations could be carried out at the premises, using measuring devices, to search for legacy sources possibly present on the site.

(2) To ensure the immediate notification of any modification of the HASS status, the national regulatory framework could define a maximum tolerated delay of a few days within which the relevant authority needs to be notified.

(3) Pending the adoption of the new EU BSS Directive, in which the HASS definition is revised, EU Member States using the definition of HASS as given in the current Directive should apply their national HASS provisions until the source is decayed below the exemption/clearance levels and not until the source activity has fallen below the high activity levels.

(4) The type and frequency of tests to be performed by the HASS holders should be defined in the regulation or in guidance elaborated by the regulatory body. These tests should be performed by a skilled person with adequate radiation protection competences. If a recognized radiation protection officer is not available among the HASS holder's staff, the tests should be carried out by a recognized organization, such as a technical support organization. In any case, the documentation recording the results of the tests on the HASS has to be checked by the authority during inspections to ensure that they were effectively performed and that the outcomes of the tests have been taken into account by the holders.

(5) The documentation accompanying the HASS should also be checked during inspections to verify its completeness as regards the requirements of the HASS Directive.

(6) To avoid the risk of loss of control of disused HASS stored at the holder's premises, the maximum allowable time for storage before mandatory transfer could be laid down in national regulations. Compliance with this requirement should be checked during inspections and the necessary enforcement actions should be taken once non-compliance is observed. To avoid undesirable situations, adequate arrangements for the long term

management of disused HASS should be a prerequisite for authorization for any practice.

(7) To ensure the proper training and information of persons in installations where orphan sources are more likely to be found or processed and in significant nodal transit points, national regulations should insist on the organization of training sessions. The requirement should impose training courses for all types of installations at risk and for both categories of people (management and workers). Both the content and the frequency of the training sessions should be either defined or approved by the relevant authority. The training and information programme should include practical exercises, such as the visual detection of sources and their containers, and actions to be taken on-site in the event of the detection or suspected detection of a source.

2.6. Identification of best practices

Based on the analysis of the level of implementation of the HASS requirements in the 27 EU Member States, several best practices were identified:

(1) The licensing process is a key step in the management of HASS. Prior authorization for any practice with a HASS could specify, for example, that adequate arrangements, including financial guarantees, have been made for the long term management of the HASS, including cases in which the holder or supplier becomes insolvent or goes out of business. The long term arrangement could exclude the long term storage of the disused HASS at the holder's premises. The authorization could also describe the tests that will be performed by the holders on the HASS and their frequency, as well as the training sessions that will be organized for the exposed workers and the frequency at which they will be repeated.

(2) To ensure the prompt notification to the authority of any change with regard to the status of HASS, a maximum tolerated delay of few days should be defined in national regulations enacting the HASS Directive.

(3) Announced and unannounced inspections are regularly carried out to check both the safety and security issues. The inspections aim at verifying all HASS records kept by the holder in order to check the correctness of the information notified to the authority. The documentation accompanying the source should also be verified. During inspections, records relating to HASS testing and the training of the staff of HASS holders are verified. In addition to these documentary checks, visual inspections of the sources and measurements are performed by the inspectors, allowing them to assess the integrity of the source and its proper use.

(4) The HASS holder's staff training programme is defined or approved by the authority and the frequency of repetition is set at a reasonable time interval (i.e. annually). The training courses are recorded and comprehension tests are organized. The training records are checked during inspections.

(5) The HASS Directive requires holders of sources to return each disused source to the supplier, place it in a recognized installation, or transfer it to another authorized holder without undue delay after it goes out of service, unless otherwise agreed by the competent authority. As "undue delay" is not precisely defined in the Directive, the period before mandatory transfer greatly varies among EU Member States, ranging from less than one year to several years or no defined time frame. The best practice consists of defining in a regulation a reasonable maximal period for removal of disused sources from users' premises (e.g. a maximum of two years). Take-back provisions alone do not guarantee the effective removal of disused sources from holders' premises. Besides, financial arrangements, such as monetary deposits by the holders or suppliers are necessary. Such arrangements, financed by the sector, could also be available for the long term management of disused HASS transferred to a recognized storage facility. Where the transfer of disused HASS to a recognized storage facility is one of the long term management options, EU Member States should provide for access to a facility of sufficient capacity.

(6) The establishment and enactment of specific provisions regulating the security and physical protection of HASS is another good practice observed in several EU Member States. The security requirements defined should be based on a graded approach, taking into account the risk posed by the sources.

(7) To avoid incidents with orphan sources, each EU Member State should identify strategic locations at which they are likely to be found or from which they can enter the country. Moreover, the regulatory authority should impose the installation of detection and monitoring equipment at these locations. Orphan source recovery campaigns should be organized, especially in old or former installations where radioactive substances were or are still used. The financial burden for recovering and managing the orphan sources should not be supported by the community through the State budget but borne by the concerned sectors. The response and alerting procedures for installations where orphan sources are more likely to be found should be approved by the authority and exercises should be organized to test them. Managers and workers potentially confronted with an orphan source in all types of installations at risk should be regularly trained in compliance with the requirements of the national regulation. The content of the training course should be either defined or approved by the

authority, which ensures that the sessions are documented and effectively given. The understanding of the trainees should be evaluated. To increase the awareness of the persons potentially confronted with orphan sources the authority may organize information sessions and develop guides, documentation, movies and posters, among other things.

2.7. Loss of control incidents in Europe

With regard to the analysis of incidents in Europe resulting from a loss of control of radioactive sources, access to information was requested from Europol, INTERPOL and the IAEA. Due to the confidential nature of the data, very limited information was provided. Information obtained from the IAEA Incident and Trafficking Database (ITDB) representative suggested that very few incidents (perhaps below ten) have involved harmful exposure and even fewer cases involving malicious intent have been reported. INTERPOL indicated that criminal incidents made up only a minor percentage — less than 8% — of all reported incidents in 2007–2009.

From the data provided by the EU Member State, it can be concluded that the discovery of radioactive sources or contaminated items in scrap metal is by far the most frequent incident encountered, occurring at scrap metal facilities and also at national borders. The second most frequent event reported by the responding EU Member States is the discovery of orphan sources. Orphan sources were discovered at children's playgrounds or public places, municipal dumps and during the take-over of facilities or on the premises of bankrupt companies.

3. EU LEGAL DEVELOPMENTS ON HASS REGULATION

3.1. HASS Directive requirements as a part of the proposed new EU Basic Safety Standards

The proposed new EU BSS Directive is expected to be formally adopted at the end of 2013. In addition to updating the current BSS Directive [4], the new Directive incorporates and updates requirements of five other existing directives, including the HASS Directive. The proposal also takes into account the latest ICRP guidance and the new International Basic Safety Standards drafted by the IAEA. When adopted, the old directives will be repealed and EU Member States will have four years to enact the new Directive in their national legislations.

There are separate chapters on the control of sealed sources and on orphan sources in the proposed Directive. These chapters include the current HASS Directive provisions, with only a few significant modifications, outlined below.

3.2. Harmonization with the IAEA

When the HASS Directive was written the activity values defined for the IAEA transport regulations (A-values) were selected as the basis for the HASS definition. Later on the IAEA developed the D-values [5] and used them as a basis for its source categorization system, which led to differing source definitions in the HASS Directive and the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [6]. The new EU BSS removes this discrepancy by adopting the IAEA D-values as a basis for the HASS definition. This means that Category 1–3 sources are required to be controlled as HASS in the European Union.

The revision was undertaken because several EU Member State authorities indicated that having two different definitions at international level is a problematic situation. The HASS Directive and the IAEA Code of Conduct on sources have similar aims, so they should be applied on the same group of sources. Also in principle, the IAEA and the European Union should seek harmonization of international standards.

It was also felt that, for many nuclides, the HASS Directive activity levels are quite low, so not all HASS sources truly "imply considerable potential risks for human health and for the environment" [1], as is stated in the Directive recitals, whereas the scientific basis for D-values is sound and to a certain degree supported by actual doses in real source accidents.

The revision was politically not entirely straightforward, since some EU Member State authorities indicated that changing their current national limits would be problematic. Moreover, since the D-values are mostly higher than the HASS Directive (A_1/100) values, the change would mean relaxing the requirements for most nuclides (voluntary removal of some sources from the HASS registers).

Table 1 presents a comparison of the old and new HASS activity limits. For most nuclides, the new definition is indeed a relaxation of requirements, since the D-values are higher than the HASS Directive values (ratio (A_1/100)/D < 1). However, in practice, most of the registered HASS sources have activities much higher than the D-value, so the group of sources falling between the old and new definition (i.e. the sources which can be removed from the HASS registers after transposition of the new BSS) is actually quite small.

TABLE 1. NUMERICAL COMPARISON OF THE ACTIVITY LIMITS OF THE HASS DIRECTIVE AND THE PROPOSED NEW EU BASIC SAFETY STANDARDS

Nuclide	HASS Directive (A_1-value/100) (TBq)	New BSS (D-value) (TBq)	Ratio (A_1/100)/D
Am-241	1.0E−01	6.0E−02	1.667
Cf-252	5.0E−04	2.0E−02	0.025
Cm-244	2.0E−01	5.0E−02	4.000
Co-60	4.0E−03	3.0E−02	0.133
Cs-137	2.0E−02	1.0E−01	0.200
Gd-153	1.0E−01	1.0E+00	0.100
I-125	2.0E−01	2.0E−01	1.000
Ir-192	1.0E−02	8.0E−02	0.125
Kr-85	1.0E−01	3.0E+01	0.003
Pm-147	4.0E−01	4.0E+01	0.010
Pu-238	1.0E−01	6.0E−02	1.667
Ra-226	2.0E−03	4.0E−02	0.050
Se-75	3.0E−02	2.0E−01	0.150
Sr-90 (Y-90)	3.0E−03	1.0E+00	0.003
Tm-170	3.0E−02	2.0E+01	0.002
Yb-169	4.0E−02	3.0E−01	0.133
Au-198	1.0E−02	2.0E−01	0.050
Cd-109	3.0E−01	2.0E+01	0.015
Co-57	1.0E−01	7.0E−01	0.143

TABLE 1. NUMERICAL COMPARISON OF THE ACTIVITY LIMITS OF THE HASS DIRECTIVE AND THE PROPOSED NEW EU BASIC SAFETY STANDARDS (cont.)

Nuclide	HASS Directive (A_1-value/100) (TBq)	New BSS (D-value) (TBq)	Ratio (A_1/100)/D
Fe-55	4.0E−01	8.0E+02	0.001
Ge-68	5.0E−03	7.0E−01	0.007
Ni-63	4.0E−01	6.0E+01	0.007
Pd-103	4.0E−01	9.0E+01	0.004
Po-210	4.0E−01	6.0E−02	6.667
Ru-106	2.0E−03	3.0E−01	0.007
Tl-204	1.0E−01	2.0E+01	0.005

For a few nuclides, the D-value is lower that the HASS Directive value (most notably ^{201}Po). For these nuclides, the activity level harmonization means stricter control requirements, although the differences between the old and new values are hardly significant in practical operation of the HASS registers.

Another important change in the HASS definition is that the definition now refers to current activity, not to the activity at the time of manufacture or placing on the market. This means that when the source activity has decayed below the D-value, it can be removed from the HASS register and no longer has to be controlled as HASS.

It should be noted that the Directive sets the minimum standard; EU Member States are free to use more restrictive requirements in their national regulations.

3.3. Other changes

Other source related changes introduced by the new EU BSS reflect the experience gained from the application of the HASS Directive and the feedback from recent radioactive source and contamination events. The most significant changes are outlined below:

— Definitions for sealed sources and source containers have been slightly modified.

— There are new requirements for metal contamination situations. A metal scrap recycling installation is required to notify the competent authority if it suspects or has knowledge of any melting or metallurgical processing of an orphan source. A requirement is that the contaminated materials are not used, placed on the market or disposed of without the involvement of the competent authority. The Member States are to encourage the establishment of systems to detect the presence of radioactive contamination in metal products imported from third countries, in places such as major metal importing installations and significant nodal transit points.
— EU Member States are required to ensure that the management of installations where orphan sources are most likely to be found or processed, including large metal scrap yards and major metal scrap recycling installations, and in significant nodal transit points, are informed of the possibility that they may be confronted with a source. If workers may be confronted with a source, they need to be advised and trained in the visual detection of sources and their containers, informed of basic facts about ionizing radiation and informed of and trained in the actions to be taken on-site in the event of the detection or suspected detection of a source.
— The HASS record sheet included in the Directive annex has been improved by updating the terminology and removing the inconsistencies appearing in the HASS Directive record sheet.
— There are new general requirements for unsealed sources. EU Member States are to ensure that arrangements are made for keeping control of unsealed sources with regard to their location, use and recycling or disposal. In addition, EU Member States are to require the undertaking, as appropriate and to the extent possible, to keep records of unsealed sources under its responsibility. EU Member States are to require each undertaking holding an unsealed radioactive source to notify the competent authority promptly of any loss, theft, significant spill or unauthorized use or release.

4. CONCLUSIONS

HASS Directive principles have been implemented well in the European Union, although there are significant differences in implementation practices among EU Member States. The low number of HASS related inquiries to the Commission over the years indicates that the Directive requirements are well understood and accepted.

The only major weak area in implementation is the organization of orphan source recovery campaigns, which have been implemented in only about 50% of EU Member States. In addition, there are areas where implementation is about

80–90% complete (undue delay in storage, training of personnel potentially confronted with an orphan source, source identification and marking).

Based on the lessons learned, the authorities of EU Member States recommend the following in order to keep radioactive sources under control and to safely manage incidents:

- Systems for ensuring traceability of radioactive sources throughout their life cycle;
- Regular inspections;
- Requirements of physical protection in high risk facilities;
- Compulsory training of the personnel;
- Border controls to detect radioactive materials;
- Exchange of information among the national and international competent authorities;
- Public information;
- Testing of pre-established plans for prevention of and for response to incidents involving HASS.

The proposed new EU BSS Directive represents a major revision of the whole EU radiation protection legal framework. Chapters concerning HASS were not difficult to include in this framework, since the HASS Directive has been well accepted by EU Member States and there was no need for major modifications in the HASS control, although the new BSS Directive corrects several deficiencies of the HASS Directive. In particular, the achieved harmonization with the IAEA regulations places EU Member States in a good position to fulfil both EU and IAEA requirements on the control of high activity sealed sources and orphan sources.

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DEVELOPING SUSTAINABLE APPROACHES TO STRENGTHEN THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES IN THE LIGHT OF SUCCESSFUL INITIATIVES

(Session 3)

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RAPPORTEURS' SUMMARY

Session 3: Developing Sustainable Approaches to Strengthen the Safety and Security of Radioactive Sources in the Light of Successful Initiatives

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This session was designed to present in more detail than in Session 2 some specific examples of initiatives taken at national, regional or international levels to strengthen the safety and security of radioactive sources, with a view to share the good practices and to ensure the sustainability of these initiatives.

Since the Code of Conduct and supplementary Guidance were published, many States have strengthened cradle to grave safety and security for radioactive materials. A number of examples described demonstrated the progress made in various States on different aspects of safety and security of sources. This progress was achieved by States through national initiatives including:

- The use of on-line source reporting, tracking and transfer notification from a shipper or receiver to the regulatory body. This should be viewed as a good practice and can be potentially implemented in any State with Internet access. In time, States could even work together to ensure compatibility to allow for sharing of on-line notifications between States or regulatory bodies.
- Practical measures, such as the mobile source on-line tracking system.

Outreach programmes such as the US Global Threat Reduction Initiative and Australia's South Pacific regional programme on technical cooperation have had a positive impact in many regions and countries. National capabilities and cooperation between Member States for searching and securing orphan sources have had a positive impact on protecting against malicious acts and unintentional incidents involving radioactive materials.

IAEA peer reviews and advisory services such as the Integrated Regulatory Review Service, the International Physical Protection Advisory Service and the International Nuclear Security Advisory Service, and the provision of resources, equipment and knowledge have assisted States with the implementation of international standards and guidance into national contexts, as well as with recovering and regaining control over orphan sources.

Education and training programmes to increase knowledge and competence are required for effective safety and security programmes regarding radioactive sources. International cooperation in this regard is also beneficial, although some specific training on security aspects may be more appropriate within a national context.

There are various options for States to develop financial precautions or guarantees to cover the costs associated with recovering orphaned sources:

— A user 'guarantee' which is deposited with the regulator/State and which is refunded when a source is properly dealt with at the end of its useful life;
— An insurance 'pool' for small users to distribute potential costs, as a licensing condition;
— Funds guaranteed by the regulator/State to recover any orphaned sources found.

From the presentations and discussions held during the session, the main conclusions were as follows:

(a) States are encouraged to benefit from the experience and the knowledge available around them to develop their national programmes and properly assume their responsibility to ensure the safety and security of sources.
(b) Regional partnerships and harmonization of regulations need support and funding if they are to survive, especially in developing countries.
(c) IAEA peer review and advisory services are a good way to improve safety and security programmes, and should be considered by States — even States with highly developed regulatory programmes.

IAEA nuclear knowledge programmes are helpful to increase knowledge and competency, and may be helpful to smaller States that may lack these fundamentals.

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SUCCESSES AND CHALLENGES IN IMPLEMENTING SUSTAINABLE APPROACHES IN CANADA TO STRENGTHEN THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

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Abstract

Over the last decade, Canada has successfully implemented measures and programmes to enhance its regulatory oversight of radioactive sealed sources to fully meet the provisions of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code) and of its supplementary Guidance on the Import and Export of Radioactive Sources (Guidance). As Canada's nuclear regulator, the Canadian Nuclear Safety Commission (CNSC) has put in place a risk informed regulatory regime for the licensing and compliance verification of nuclear related activities involving the use of sealed sources of all categories (i.e. Categories 1–5 under the Code). This has evolved to a mature regulatory system whereby the CNSC is able to exercise complete control over radioactive sealed sources from cradle to grave. The CNSC's regulatory regime not only encompasses risk informed licensing and compliance, but also includes effective measures and programmes for sealed source tracking and registration, import/export, management of disused and orphan sources, event tracking and reporting, physical security, and information dissemination.

The paper provides an overview of the key successes achieved in Canada over the ten years of implementation of the Code and its Guidance. The paper highlights some lessons learned and main challenges in implementing sustainable approaches to strengthen the safety and security of radioactive sources. These approaches have proven to be successful in supporting international efforts to attain the goals established under the Code and its Guidance.

1. INTRODUCTION

The Canadian Nuclear Safety Commission (CNSC) is the national competent authority under Canada's Nuclear Safety and Control Act (NSCA) to regulate the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to ensure the implementation of Canada's international commitments on the peaceful use of nuclear energy.

From the publication in 2004 of the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1], and from 2007, when the Code's supplementary Guidance on the Import and Export of Radioactive Sources (Guidance) [2] was implemented, Canada was among the first Group of Eight (G8) countries to adopt and implement the Code and Guidance as part of its nuclear regulatory system.

Being a global leader in the manufacture, supply and export of high risk radioactive sources that fall under the purview of the Code and Guidance, Canada continues to support the establishment and maintenance of an effective, efficient and harmonized international regime to ensure the safety and security of such sources.

Over the close to ten years of implementation of the Code and Guidance in Canada, the CNSC has successfully implemented a risk informed regulatory framework and processes designed to optimize resource allocation and decision making across its entire regulatory programmes, particularly in licensing and compliance verification for all of the facilities and activities it regulates. This has resulted in a regulatory oversight regime for radioactive sources of all categories that has evolved to become a mature regime whereby the CNSC is able to exercise complete control over radioactive sealed sources in Canada, from cradle to grave.

The following presents an overview of the key successes achieved in Canada over the ten years of implementation of the Code and its Guidance, highlighting some lessons learned and main challenges in implementing sustainable approaches to strengthen the safety and security of radioactive sources.

2. REGULATORY STRUCTURE/POLICY/PROGRAMMES

The CNSC has in place a clear, pragmatic and comprehensive regulatory framework for facilities and activities it regulates under the NSCA, which ensures effective regulatory oversight of radioactive sealed sources. This regulatory framework encompasses not only the NSCA and its regulations, licences and certificates, but also regulatory guidance documents and bilateral arrangements with domestic and foreign partners. The framework covers all aspects of the Code and Guidance pertaining to safety, security and import/export of radioactive sealed sources.

The regulatory framework encompasses risk informed licensing and compliance processes requiring licensees and other persons regulated under the NSCA to demonstrate that their activities are safe and secure. These regulatory processes are designed to optimize resource allocation within the CNSC and decision making across the entire nuclear regulatory programme, particularly in licensing and compliance activities related to radioactive sources. As a result, the CNSC is able to exercise effective regulatory control.

Under the CNSC's regulatory regime, any person who uses, possesses, stores, imports or exports sealed radioactive sources need to do so in accordance with a licence, unless such activity is exempted under CNSC regulations. The transportation of sealed sources does not require a CNSC licence in most cases. However, carriers are still required to comply with CNSC and other federal transport regulations.

3. SEALED SOURCE TRACKING AND THE NATIONAL REGISTRY

Over the last decade, the CNSC has had great success in implementing effective measures for the control of sealed sources. These measures meet or exceed Code provisions.

In 2006, the CNSC was the first nuclear regulator among the G8 countries to establish a National Sealed Source Registry (National Registry) for the consignment of sources of all categories (i.e. Categories 1–5), and a web based Sealed Source Tracking System (Tracking System) for real time tracking and reporting of high risk sources (i.e. Categories 1–2). Accordingly, all licensees of high risk sources are required by their licence to report all transfers of high risk sources within specified strict timelines.

Since their inception, the National Registry and Tracking System have enabled the CNSC to build an accurate and secure inventory of sealed sources in Canada. In addition to the mandatory tracking and reporting by licensees of transfers of high risk sources (Categories 1 and 2), licensees also have to report their inventories of Categories 3–5 sources on an annual basis through the submission of their annual compliance reports to the CNSC. Consequently, the National Registry now contains data on more than 50 000 sealed sources of all categories.

Over the years, the CNSC has made several enhancements to these two systems to maintain them with up to date components and ensure compliance with Canadian government wide requirements for on-line services. For example, in 2010 the CNSC added a bulk upload tool to enable sealed source manufacturers to perform multiple transactions in a single file upload. In 2012, 86% of the transactions (57 779) performed through the Tracking System were done via the web interface, demonstrating that the on-line interface has been well adopted by the Canadian licensees. The remaining transactions were conducted by phone, fax, mail and email.

As part of its compliance verification programme, the CNSC monitors licensee conformance with regulatory requirements by performing on-site inspections and desktop reviews. Compliance verification with the reporting of Category 1 and 2 sources conducted since 2010 demonstrates that 94% of the licensees comply with CNSC requirements related to tracking and reporting of high risk sealed sources. This high degree of compliance indicates that the CNSC's regulatory framework has been effective in controlling high risk sources. The CNSC took appropriate measures where non-compliance was observed, in order to have licensees correct problems promptly and satisfactorily.

4. IMPORT AND EXPORT CONTROLS

The CNSC has been successful in enhancing national and international safety and security by implementing the Guidance since 2007, ensuring that only authorized persons are recipients of Category 1 and 2 sources within Canada and abroad. This approach makes the CNSC import and export control programme for Category 1 and 2 sources fully consistent with the Code and Guidance.

The programme encompasses licensing, compliance, prior shipment notifications to importing States, post-shipment verifications, State to State requests for import consent for Category 1 sources, the establishment of bilateral administrative arrangements, and the confirmation of receipt of radioactive sources as negotiated in several bilateral administrative arrangements.

To assist the international implementation of the Code and Guidance in a harmonized manner, the CNSC has developed a model bilateral administrative arrangement with a core set of terms, definitions and procedures. The CNSC also continues to enter into bilateral administrative arrangements with its international counterparts to ensure that imports and exports of Category 1 and 2 sources between Canada and these countries are conducted in a manner consistent with the Code and Guidance. To date, the CNSC has established 12 such arrangements.

However, the CNSC's regulatory oversight of sealed sources is being impeded by its organizational structure. This is because the licensing functions for the possession and use of sealed sources are dealt with by an operational unit, and the import/export functions are dealt with by a technical unit, as opposed to all of these functions being consolidated into a single unit. This makes it difficult for the CNSC to implement efficient regulatory measures in these respects. It is also challenging for licensees who have to deal with different entities at the CNSC for their licensed activities involving sealed sources. This will remain a challenge until the CNSC finds a way to efficiently consolidate these functions.

5. SECURITY OF SOURCES

In the aftermath of 11 September 2001, the CNSC increased its focus on developing tighter security controls for high risk sealed sources while maintaining effective security oversight on lower risk sources. As such, the CNSC augmented its resources in this area and successfully put in place a risk informed regulatory strategy that encompasses prescriptive and performance based requirements for the security of sealed sources of all categories. Hence, security requirements correspond to the risk associated with the sealed source category and complement mandatory requirements already established under CNSC regulations.

CNSC efforts to implement its regulatory strategy have also culminated in the recent publication of a CNSC regulatory document on the security of sealed sources that are in storage or being transported. The document provides clear objectives and criteria for licensees to meet CNSC regulatory requirements in finding the appropriate security solutions that are commensurate with the category of sources at hand.

The regulatory strategy on security of sealed sources is being well integrated with safety measures and practices currently in place for sealed sources and does not place an undue burden on the regulated community. Through internal administrative arrangements within the CNSC, staff responsible for licensing and compliance verification work hand in hand with security specialists to ensure that licensees meet all security requirements and implement adequate corrective measures to address any deficiencies.

6. LONG TERM MANAGEMENT OF DISUSED SOURCES

As one of the measures to ensure that disused sources are properly dealt with at the end of their useful life, the CNSC endorses the recycling and reuse of sources where possible. As such, sources may be returned to the manufacturer in Canada or to their country of origin, or transferred to a person licensed to possess the sources. Where this may not be appropriate or possible, licensees can send disused sources for disposal at a licensed waste management facility. If a source has decayed below its exemption quantity or its clearance levels, it may also be released from CNSC regulatory control. Even though the sources may no longer be under CNSC regulatory control, persons possessing them still need to follow applicable federal, provincial and/or municipal regulations.

7. DEALING WITH ORPHAN SOURCES

In 2010, the CNSC successfully developed and put in place an enhanced regulatory strategy for dealing with orphan sources. This strategy aligns well with its regulatory processes and the future establishment of financial guarantees for users of sealed sources.

As part of its strategy, the CNSC has increased communication and awareness with the metal recycling industry and conventional waste facilities. For example, the CNSC has developed and distributed an information poster and a brochure, specifically for radiation portal monitor users; these products focus on identifying and managing orphan sources. In addition, the CNSC has incorporated the topic of orphan sources in its existing outreach programmes to the licensed community across the country.

The CNSC now has better tools in place to identify the owners of orphan sources who have ultimate responsibility for their safe disposal. Other appropriate measures are also in place to deal with orphan sources should the owners not be found. CNSC staff are aware of and familiar with the actions to be taken following the discovery of an orphan source and are able to effectively deal with all stakeholders.

In addition, the CNSC is leading an initiative to establish a financial guarantees regime for Canadian licensees who use sealed sources in the medical, industrial, commercial, and academic and research sectors. This will help ensure that funds are available to cover the costs associated with the remediation of a location as a result of the termination of licensee operations, as well as with the safe disposal of any sealed sources left behind.

8. DISSEMINATION OF INFORMATION RELATED TO SEALED SOURCES

In 2012, the CNSC upgraded its existing database of events and incidents reported to the CNSC in order to ensure a consistent approach in recording information being reported to the CNSC and, in turn, to the public, the IAEA and other stakeholders. The new system captures events related to lost, stolen and found nuclear substances, as well as all other reportable events, including illicit trafficking.

Since 2006, the CNSC has been publishing a report on the National Sealed Source Registry and Sealed Source Tracking System. This annual report provides an overview of past and future system improvements as well as operational data contained in the system.

The CNSC also published guidance on the control of the export and import of risk significant radioactive sources in order to further assist Canadian exporters and regulatory counterparts in understanding the implementation of the Canadian export and import controls programme.

In 2011, the CNSC published the first edition of Nuclear Substances in Canada: A Safety Performance Report, an annual report that provides an overview of the safety performance of the nuclear sectors regulated by the CNSC with respect to the use of nuclear substances in medical, industrial and commercial applications, as well as for academic and research purposes. The first edition covered the calendar years 2008 and 2009. Since that time, two additional editions, covering 2010 and 2011 respectively, have been published. This comprehensive report includes performance results related to the Tracking System requirements and four other performance measures for the year reported, along with trending information relative to previous years.

9. CHALLENGES FOR THE CNSC

The CNSC has made continuous efforts in developing and nurturing the safety culture within the regulated community in Canada. In recent years, with respect to sealed radioactive sources, focus has been placed on enhancing safety culture in the industrial radiography community, a group of licensees working with high risk sealed sources. In 2009, the CNSC established a joint CNSC/industry working group to collaborate on implementing solutions to promote compliance with regulatory requirements and a strong security and radiation safety culture while respecting and understanding the interests and expectations of stakeholders. The working group has been meeting twice a year since 2010. This effort is ongoing and will be expanded to include other groups of licensees in the near future.

Certain source manufacturers are recycling sealed sources at the end of their useful life by either reusing decayed sources for other applications, re-encapsulating them or reprocessing them for other useful applications. The CNSC recognizes that these are good practices and is working on improving its National Registry and Tracking System to ensure that the data on these recycled sources are linked to their new applications.

Sources are still frequently received in Canada without prior shipment notification, which is of concern to the CNSC, especially when the shipment involves Category 1 sources. Although no instances of loss or diversion of Canadian origin sources have been identified, establishment of international procedures to confirm receipt of exported sources would further enhance the safety and security of such sources. To address this problem, the CNSC has begun including a confirmation of receipt provision in several current bilateral administrative arrangements.

Within the CNSC, as mentioned in the foregoing, internal misalignment also remains, which sometimes makes licensing of uses of sealed sources and their import/export inefficient, as these functions are assumed by different service lines. The CNSC will need to find a way to consolidate these functions such that licensing of sealed sources can be done in a consistent manner.

In recent years, the CNSC has held discussions with the United States Nuclear Regulatory Commission (NRC) regarding the feasibility of an electronic exchange of sealed source information between the CNSC's Sealed Source Tracking System and the NRC's National Source Tracking System. This exchange of data would provide essential information on authorized sealed source import and export transactions between Canada and the United States of America, allowing for a continued tracking of sources in the respective systems. In 2012, the CNSC and NRC successfully conducted data exchange testing, with potential further development on this initiative in the future.

10. LOOKING INTO THE FUTURE

In July 2013, new regulations were adopted that allow the CNSC to issue administrative monetary penalties to licensees and other regulated persons who are found in violation of regulatory requirements. This gives the CNSC an additional enforcement tool to ensure compliance with its regulatory requirements.

The CNSC always strives to improve efficiency in the way it regulates the nuclear industry, including radioactive sealed sources. As such, in 2012 the CNSC began a review of its risk informed compliance verification programme with respect to sealed sources, in order to update the risk ranking of the various activity types for the purpose of compliance verification. This will help the CNSC to better allocate resources where non-compliance situations or events are more likely.

The CNSC is also looking to transition to e-business with the regulated industry with respect to licensing, compliance verification and reporting. Options are currently being examined to find solutions that would offer suitable levels of services that would satisfy both regulatory and industry interests.

In addition to these regulatory improvement initiatives, the CNSC has initiated the following enhancements to its regulatory programmes:

— Developing web pages to provide information on CNSC requirements and guidance, with respect to the Code and radioactive source safety and security;

— Further enhancing the National Registry and the Tracking System so that the information on sealed sources that have decayed below their exemption quantity is retained but the sources are no longer considered active.

11. CONCLUSION

Canada continues to demonstrate full commitment to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [1] and its supplementary Guidance on the Import and Export of Radioactive Sources [2].

Over the last decade, the CNSC has made numerous improvements to its regulatory oversight of radioactive sealed sources by implementing sustainable, risk informed approaches to strengthen the safety and security of sealed sources. Successful initiatives implemented in Canada in the areas of sealed source tracking and registration, risk informed licensing and compliance, import/export controls, management of disused and orphan sources, physical security, and information dissemination have all contributed to enhancing international efforts in achieving the goals established in the Code and its Guidance for the safety and security of radioactive sources. The CNSC is committed to further improvements of present and future programmes and will continue to monitor these initiatives to ensure that they are working to achieve their intended objectives.

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IAEA-CN-204/241

SUCCESSFUL KOREAN INITIATIVES FOR STRENGTHENING SAFETY AND SECURITY OF RADIOACTIVE SOURCES

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Abstract

To enhance the safety and security of radioactive sources, the Republic of Korea has taken several initiatives which include the development and operation of the web based Radiation Safety Information System and the Radiation Source Location Tracking System. In addition, radiation portal monitors have been installed and operated at ports to monitor radioactively contaminated scrap metal. The volunteer based Ubiquitous Regional Radiation Emergency Supporting Team, together with the police and fire brigade, greatly helped to take first response to radiological emergency including loss or theft of radioactive sources. The Republic of Korea continues bilateral and multilateral cooperation projects.

The paper introduces the status of regulatory framework for control and management of radioactive sources and successful Korean initiatives to strengthen safety and security of radioactive sources. The initiatives include information technology based systems to trace down the life cycle of radioactive sources and to monitor the real time location of radioactive sources. The paper also presents Korean efforts such as radiation monitoring at ports, organizing and training of first responders to radiological emergency and finally international cooperation to joint technical projects.

1. REGULATORY FRAMEWORK AND STATUS ON THE USE OF RADIOACTIVE SOURCES

The Nuclear Safety and Security Commission (NSSC) is the government regulatory authority responsible for overall safety and security management of radioisotopes and radiation generators at all stages from import and/or production to disposal. The NSSC was established in accordance with the Act on the Establishment and Operation of the Nuclear Safety and Security Commission and is organized in accordance with the Enforcement Regulation on the Organization of the Nuclear Safety and Security Commission. The Korea Institute of Nuclear Safety (KINS) is the technical authority responsible for regulatory review, assessment and inspection for the safety and security of radiation sources and their transport, among other things. Figure 1 shows the regulatory framework in the Republic of Korea.

The number of radioisotope and radiation generator users in the Republic of Korea has been growing steadily by about 10% annually, reaching about 6000 as of 7 October 2013. The number of licensed users is 1371 and the number of registered users is 4598. Figure 2 shows the trend in the use of radiation sources in various sectors.

2. LIFE CYCLE MANAGEMENT AND SOURCE LOCATION TRACKING SYSTEM OF RADIOACTIVE MATERIALS

The number of users of radioisotopes in the Republic of Korea is continuously increasing. In addition, the IAEA requires each State to manage and control the amount of radioisotopes systematically. To meet these needs, the Radiation Safety Information System (RASIS), a web based information system, was developed, and it has been operated to meet the national demands for a total management and control of integrated radiation safety.

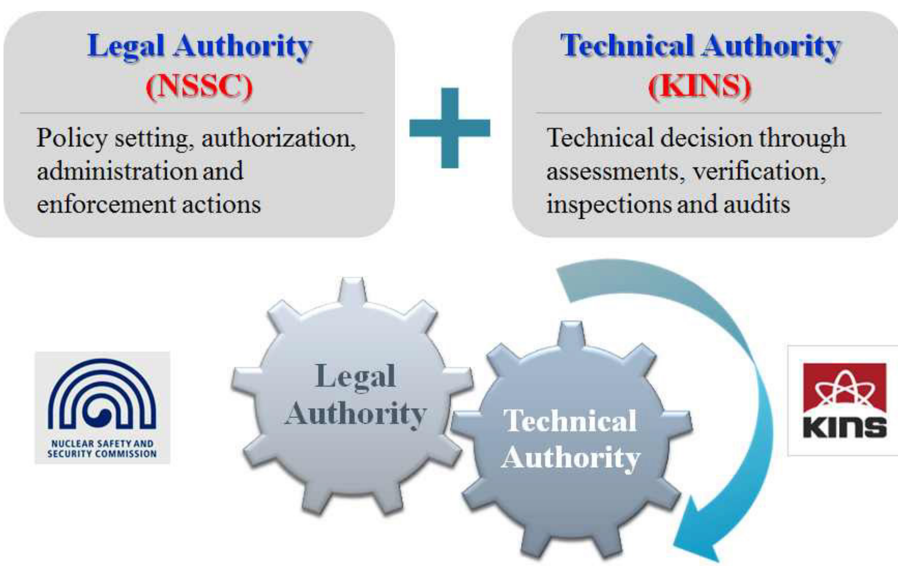

FIG. 1. Regulatory framework for radiation sources.

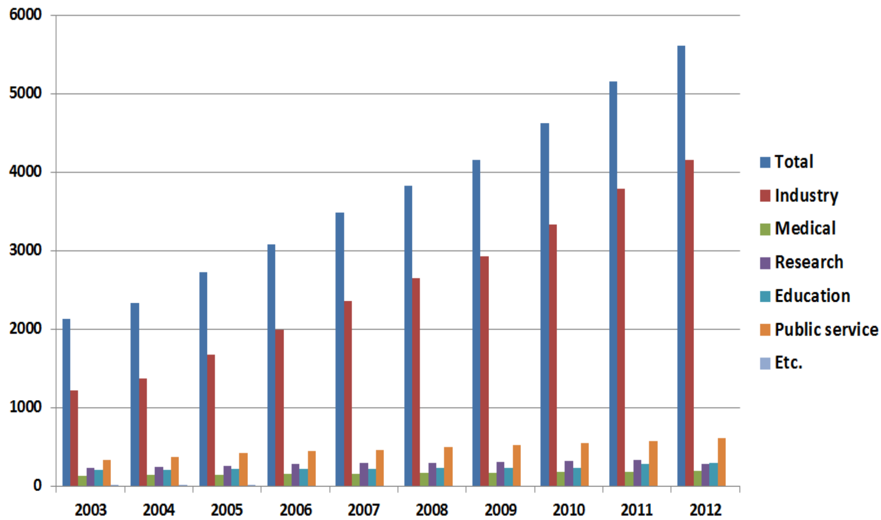

FIG. 2. Trend in the use of radiation sources in various sectors.

RASIS is an integrated management system of radiation safety which is used by government and other related agencies such as the NSSC, KINS, the Korea Radioisotope Association and more than 5800 radiation users. It can be connected to radiation safety management system for radiation users, regulatory information system, radiation safety management system for related organizations, and radiation source tracking system, as shown in Fig. 3. This system effectively monitors and traces down the life cycle of radioactive sources and its inventory, while it serves and provides much useful information to both licensees and regulatory authorities. Figure 4 shows a business flow diagram of RASIS.

The Radiation Source Location Tracking System (RADLOT) is a system for quick recovery of the misplaced or thieved radioactive sources and minimizing the emergency situation. RADLOT, which can track the positions and the routes of the industrial radiography sources on a real time basis using the Global Positioning System (GPS), has been developed by KINS.

This system consists of a central control centre at KINS, a mobile communication agency, GPS terminal, operator and user, as shown in Fig. 5. The GPS terminal fixed to an irradiator collects the location and status information. The mobile communication agency calculates this collected location information and transfers calculated data to a central control centre at KINS. This centre processes the data and offers them to operator and users. It allows for real time monitoring of irradiators around the clock by presenting the location information sent from the GPS location tracking device in conjunction with the geographic information, regularly or at the user's request, using the CDMA network.

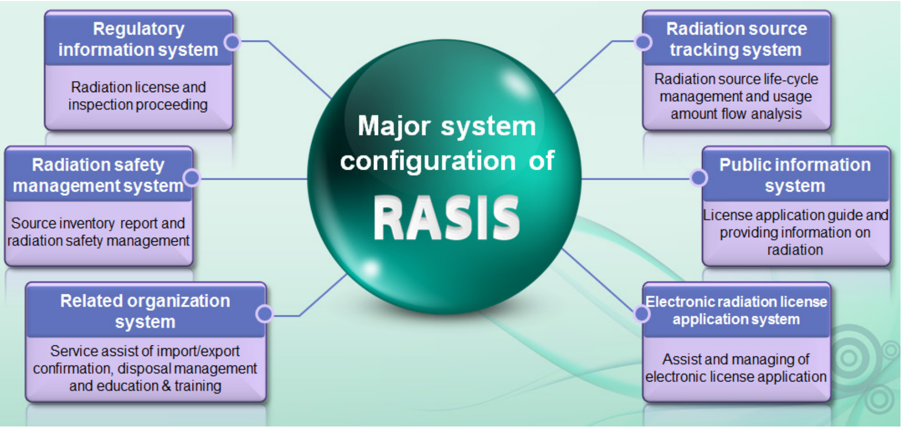

FIG. 3. System configuration of RASIS.

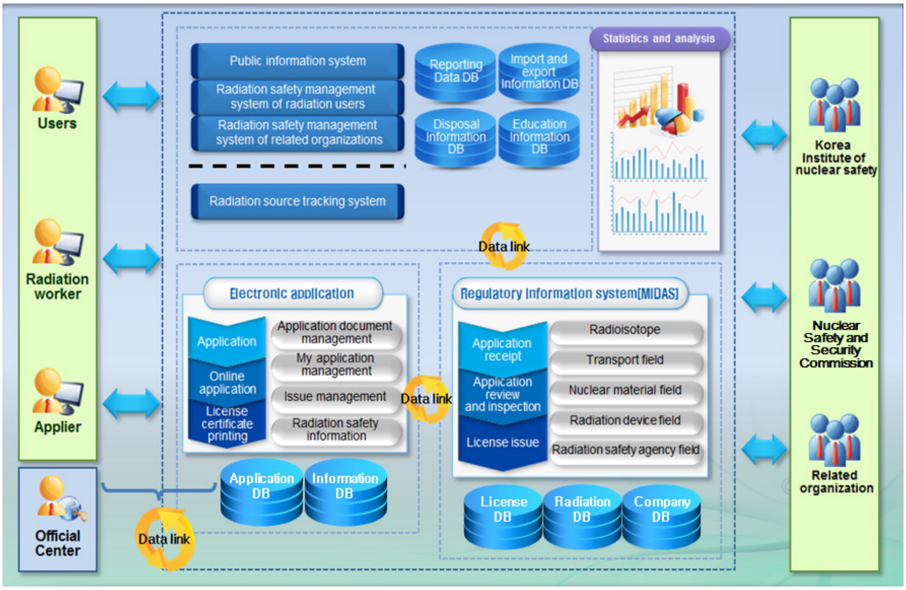

FIG. 4. Business flow diagram of RASIS.

RADLOT was developed and tested for two years, and it has been in normal phase operation since March 2006. The first GPS terminal is called by START, of which there are several types. START-I, a first model was operated in 2006. In 2007, the features were extended beyond its original function of location tracking to monitor the radiation dose. The START-II device was developed to minimize

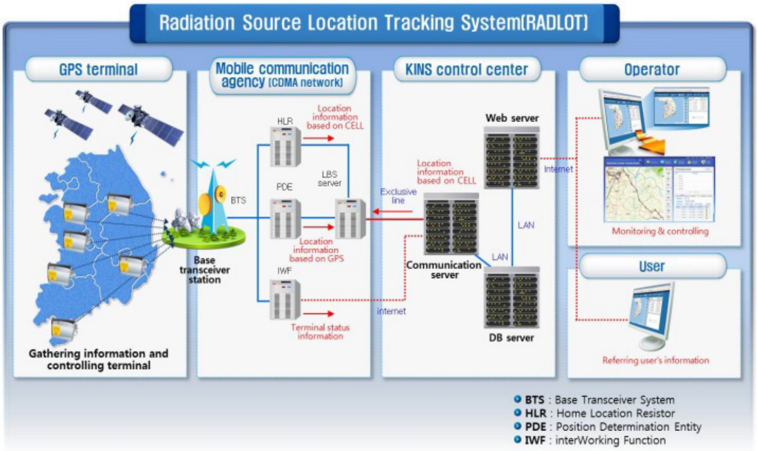

FIG. 5. System configuration of RADLOT.

damage to residents in the event of a radiation accident and has been under a trial run (attached to irradiators) since 2008.

Currently, 1400 GPS mobile terminals are in operation in the Republic of Korea. Thus, with the continuous development and operation of this system, the security and safety control of radioactive sources has been strengthened even further to prevent the loss and theft of radioactive sources.

The transmitted data on the locations of radiation source is displayed via geographic information system using the digital map provided by the central control system at KINS. Figure 6 shows the track of a radiography source.

A pilot technical project by the IAEA, the Republic of Korea and Viet Nam is underway as a follow-up action of the 2012 Seoul Nuclear Security Summit. Its purpose is to operate RADLOT in Viet Nam. In addition, KINS has recently started a dialogue with United States Department of Energy on sharing successes and challenges of RADLOT from Korean experiences.

3. RADIATION MONITORING AT PORTS

The Republic of Korea has operated ten radiation portal monitors (RPMs) at major seaports since 2012 by the Act on Protective Action Guidelines against Radiation in Natural Environment. In 2012, ten RPMs were installed at four major seaports (Incheon, Pyeongtaek, Busan and Pohang). In 2013, 22 RPMs were being installed at six seaports. The purpose of the operation of RPMs is to monitor radioactively contaminated scrap metal and naturally occurring

FIG. 6. The track of a radiography source.

radioactive material for registration from imported cargos. Around 100 RPMs will be operating at airports and seaports after 2016.

The Republic of Korea has participated in the Megaport Initiative since March 2011. The Megaport Initiative monitors illicit nuclear materials and radioactive sources at the major ports arranged by the National Nuclear Security Administration of the United States Department of Energy. RPMs have been operated by the Korea Customs Service at Busan Port. According to the Megaport Initiative Alarm Response Procedures, cargos bounding to the United States of America have to pass through the radiation monitors. If any alarm occurs, a second check and inspections are performed. The Republic of Korea prepared for the national emergency response procedures and established a video conference system between the site and KINS to respond to radiological emergency effectively.

4. OTHER INITIATIVES

Training for first responders, including the fire brigade and police, on initial radiological emergency response has been implemented since 2007. Lectures on basic theory, simulation drills and professional advice were delivered to the first responders. The Ubiquitous Regional Radiation Emergency Supporting Team (U-REST) was organized and has been in operation since 2007. It is organized as local civil radiation experts for initial response to radiological emergencies.

The International Physical Protection Appraisal Service (IPPAS) mission to the Republic of Korea, scheduled from 24 February to 7 March in 2014 (two weeks) covers five modules:

— National regime;
— Facility regime;
— Transport security;
— Radioactive sources security;
— Cybersecurity.

The Republic of Korea prepared for the IPPAS mission by amending the relevant domestic regulations to reflect the IAEA recommendations related to the security of radioactive sources.

The Korean government supported the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources [1] in April 2004 and the Guidance on the Import and Export of Radioactive Sources [2] in September 2012. The Republic of Korea also joined the IAEA programmes related to nuclear security such as the Incident and Trafficking Database and the International Nuclear and Radiological Event Scale. The Republic of Korea is a signatory to international conventions such as Convention on Early Notification of a Nuclear Accident, and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The Republic of Korea has also collaborated with the international organizations such as the Global Initiative to Combat Nuclear Terrorism and the World Institute for Nuclear Security.

5. CONCLUSIONS

The Republic of Korea has taken initiatives to enhance the safety and security of radioactive sources. The information technology based systems such as RASIS and RADLOT have contributed to the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources [1] and the Guidance on the Import and Export of Radioactive Sources [2]. The experience of training and operation of volunteer based U-REST, together with the police and fire brigade, can also be an example for the first response to radiological emergency in other States. Finally, the Republic of Korea will continue bilateral and multilateral cooperation projects for the global safety and security of radioactive sources.

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THE GERMAN REGULATORY SYSTEM TO CONTROL RADIOACTIVE SOURCES

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Abstract

An effective regulatory infrastructure and control of radioactive sources and other radioactive material as well as a safe and secure long term management of disused sources are key elements for preventing people, goods and the environment from unjustified exposure. To ensure a sustainable control of high radioactive sources, the European Commission published Council Directive 2003/122/Euratom of 22 December on the control of high-activity sealed radioactive sources and orphan sources, which had to be transferred into national legislation by all EU Member States. Germany implemented this Directive, legally binding it in legislation in 2005. A major requirement of the Directive is a system to ensure traceability of high activity sealed sources from ‘cradle to grave’ as well as the provision to take back disused sources by the supplier or manufacturer.

Strengthening the security regime for other radioactive material is a topical task in Germany. Therefore, a comprehensive guideline to provide appropriate security is currently being developed in Germany. This guideline represents an efficient instrument for the security of other radioactive material during use, storage and transport in Germany. Securing other radioactive material is to a certain extent impaired by the fact that in many cases people handling these sources are well aware of their radiation safety hazard but far less aware of the security risks involved. Therefore, it is an important task to enhance awareness for the security of other radioactive material, especially at less secure sites.

1. INTRODUCTION

Radioactive sources and other radioactive material are widely used in industrial, medical and research applications. Suppliers, which can be found in a number of countries, have built effective distribution networks and deliver radioactive sources across borders. Common applications like cancer treatment, medical diagnostics, well logging, radioisotope thermoelectric generators and irradiators (blood, industrial and seed) are based on isotopes such as ^{241}Am, ^{252}Cf, ^{60}Co, ^{137}Cs, ^{192}Ir, ^{238}Pu, ^{75}Se, ^{90}Sr and ^{169}Yb. Effective regulatory control is essential to ensure the safe and secure use of radioactive material and the appropriate handling of radioactive waste. Consequently, international standards and conventions have been improved and the regulatory infrastructure of many States has been enhanced.

Given the fact that radioactive sources are readily available all over the world, the threat associated with them needs to be adequately addressed and security measures for radioactive sources have to be given enhanced consideration.

These threats comprise:

— Accidents following loss of control over, improper use or improper disposal of radioactive sources (disused and orphan sources);
— Malevolent use ranging from illicit trafficking to the potential use by terrorists.

Based on the IAEA recommendations given in the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [1], Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS Directive) [2] was issued, which is mandatory for all EU Member States. The HASS Directive was implemented into German legislation by the Act on high activity sealed radioactive sources (Act on HASS) [3] in August 2005.

Within this paper, the following definitions are used for radioactive substances:

(a) **Radioactive material**: Any material designated in national law, regulation, or by a regulatory body as being subject to regulatory control because of its radioactivity.
(b) **Radioactive source**: As defined in the Code of Conduct;
(c) **Nuclear material**: Material listed in the table on the categorization of nuclear material, including material listed in footnotes, in section 4 of IAEA Nuclear Security Series No. 13 [4] (as defined in the Convention on the Physical Protection of Nuclear Material).

(d) **Other radioactive material**: Any radioactive material that is not nuclear material.

2. REGULATORY FRAMEWORK IN GERMANY

2.1. General

The German governmental system is a federal system of 16 independent Federal States (*Länder*). The responsibilities for legislation and law enforcement are assigned to the regulatory bodies of the Federation and the *Länder* according to their scope of functions. Specifications are given by provisions of the Basic Law of the Federal Republic of Germany.

The Federal Government has the legislative competence for the use of nuclear energy for peaceful purposes. Further development of the nuclear law also lies within the responsibility of the Federation. The *Länder* are involved in the procedure.

According the Atomic Energy Act [5] in conjunction with Articles 85 and 87c of the Basic Law, the Atomic Energy Act and the statutory ordinances based thereon are executed — with some exceptions — by the *Länder* on behalf of the Federation. In this respect, the *Länder* authorities are under the supervision of the Federation with regard to the legality and expediency of their actions. The Federal Government has to ensure a uniform implementation and legality, which is called expedience supervision.

The legislative framework in Germany consists of a hierarchically structured set of regulations: The prime legal framework is provided by the Atomic Energy Act as the legal basis for licensing and supervision. The second level comprises of national ordinances such as the Radiation Protection Ordinance [6]. The next level consists of a wide range of guidelines and technical directives (see Fig. 1).

Guidelines are binding for any competent authority of a Federal State and transposed via licence obligations or supervising procedures to the user of radioactive material.

2.2. Legal requirements for safety and security of other radioactive material

2.2.1. Use of other radioactive material

The use of other radioactive material in Germany is subject to government supervision (according to the Atomic Energy Act) and requires a licence covering safety and security if their radioactivity lies above the radionuclide specific

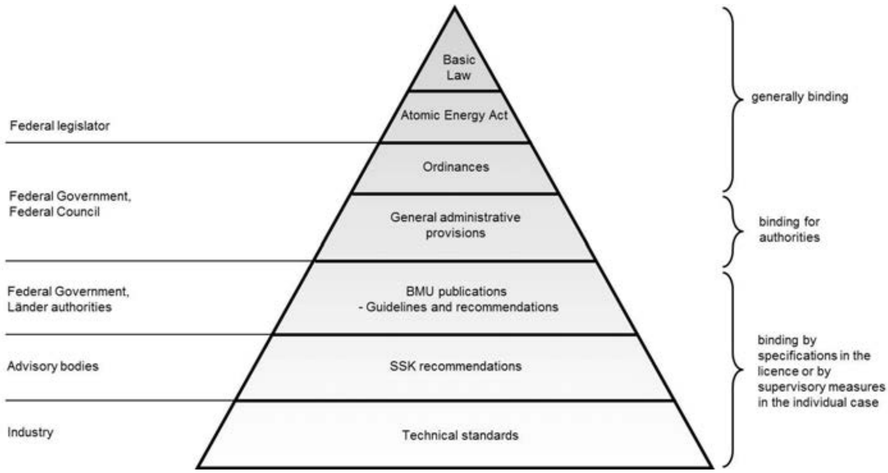

FIG. 1. Hierarchy of legislation in Germany.

exemption level defined in the Radiation Protection Ordinance following the European Basic Safety Standards [7].

The licence is granted by the respective Federal State authority in Germany after examination of legally required prerequisites. The use of sealed radioactive sources and other radioactive material without any authority control applies only to sources, that contain a level of activity below the so called exemption level, or radioactive sources which are fixed within equipment built to a type approved design. The exemption levels concur with international (IAEA) and European values (Directive 96/29/Euratom [7]). The exemption level represents an amount of radioactive material that is — if properly handled — associated with a negligible radiological hazard.

The receipt and transfer of radioactive sources and other radioactive material is also subject to governmental licensing. The correct handling during the application of radioactive sources is monitored by a radiation protection officer recognized by the competent authority. In addition, the licensee may be at any time subject to control by the competent authority which it deems necessary. Safety related incidents during the use of a sealed source and radioactive material, such as technical malfunctions of the device, operating error or theft, need to be reported immediately to the competent authority.

When transferring a source, it needs to be guaranteed that the recipient has a valid licence for the use of sealed sources. Furthermore, the recipient needs to receive a certificate, stating that the source is leak tight and free from contamination.

2.2.2. Transport of radioactive material

The transport of a radioactive source or other radioactive material is subject to the regulations for the transport of hazardous goods and requires authorization. The transport without governmental monitoring is permitted only for levels of activity below the exemption level (see above) and for so called exempted packages. The transport packaging of radioactive sources needs to comply with the provisions of the European agreements concerning the international carriage of dangerous goods.

The authorization of storage and transport of nuclear material is a Federal responsibility, carried out by the Federal Office for Radiation Protection as the competent authority, which grants licences for the transport of nuclear material and of specific HASS (>1000 TBq) within Germany. The supervision of the transport of the nuclear fuel is in the responsibility of the Federal State Authorities, except for transport by rail, which is in the responsibility of the Federal Railway Authority (Eisenbahn-Bundesamt), and by air, which is in the responsibility of the Federal Office for Civil Aviation (Luftfahrt-Bundesamt).

2.2.3. Transboundary transport

To ensure safety and security of radioactive sources, the transboundary transport (import or export) has to be conducted in such a manner that a permanent regulatory control by authorities is possible. Transboundary transport of other radioactive material is regulated in the German Radiation Protection Ordinance. No licence is necessary for a transport of sources between EU Member States, but the authority of the recipient country has to confirm that they meet the legal requirements on safety and security. In Germany, a licence is necessary for the import/export of a source with an activity greater than or equal to A1 (international transport regulations) to or from a country outside the European Union. For sources with activities between 1/100 A1 (legal definition for HASS) and A1, a notification to the competent authority is necessary. The competent authority for the export and import of HASS, among other things, is the Federal Office for Economics and Export Control. If a radioactive source is going to be imported to Germany, the supplier is responsible to ensure that the recipient of the source has the appropriate licence according to German legislation.

2.2.4. Disposal of radioactive material

The working life cycle of the applied sealed sources varies broadly, in particular due to the strongly varying half-life of the used radionuclides. If sealed sources are not disposed of directly by the licensee, the equipment together with the source remaining in the device needs to be returned to the equipment manufacturer after end of use. The manufacturer checks whether the radioactive source is reusable. If not, it is returned to the source manufacturer. Disused sources or devices are delivered to Federal State collecting facilities. The radioactive waste from industry and research and small amounts of radioactive waste from medicine (less than 0.5%) accruing on the territory of the respective Federal State is temporarily stored in these facilities until its disposal in a Federal final repository. The German final repository for low level and intermediate level waste will be the Konrad mine in Lower Saxony. Type approved devices are to be delivered to the holder of the type approval immediately after their end of use.

2.2.5. Specific regulations for high activity sealed sources

As an EU Member State, Germany had to implement the HASS Directive. The key regulations of the HASS Directive regarding high activity sources are:

— Requirements for the identification and documentation of HASS;
— Specific regulations for the leakage tests of HASS;
— The obligation to take back a disused HASS by the supplier or manufacturer;
— Financial precautions for orphaned sources;
— A system to ensure the traceability of high activity sealed sources from ‘cradle to grave’.

The most important requirements implemented in the German legislation are:

(a) Every high activity sealed source has to be registered by the licensee and is recorded in a central database, the national HASS register, which is operated by the Federal Office for Radiation Protection. The registry allows both Federal as well as Federal State authorities to trace back the registered sources within Germany and to verify whether the use of HASS by licensees is in compliance with their licence. Any notification has to be done using the standard record sheet of the HASS Directive, which has been adopted in detail by the German Radiation Protection Ordinance.
(b) HASS are delivered to the manufacturer, supplier, importer or another holder of a licence after their end of use or stored as radioactive waste in an interim storage facility.
(c) Anyone who has manufactured or shipped high activity sealed sources has to take them back or has to ensure that they are taken back by third parties in a safe manner.
(d) Leakage tests on a regular basis are mandatory.

(e) If HASS are going to be imported or exported, the Federal Office for Economics and Export Control will be involved. As mentioned before, the import of HASS with an activity above the A1 value requires a licence.

3. SAFETY AND SECURITY RELEVANT EVENTS INVOLVING RADIOACTIVE SOURCES

In 2012, Germany registered a total of 5568 licensees with practices involving sealed radioactive sources, whereof 11% were used in the medical area including research, 6% in research outside medicine, 73% in industry (whereas 7% in non-destructive testing) and 10% in other resorts.

Despite of the comprehensive governmental controls for the use of radioactive sources, it cannot be excluded completely that a sealed source may become lost or stolen or that an orphaned source will be found. These incidents need to be reported immediately to the regulatory authority or to the responsible law enforcement agencies, as regulated by the Radiation Protection Ordinance.

From 2002 to 2011, 890 radiological incidents associated with the use of radioactive material were registered by the competent authorities in Germany. Around 40% of the incidents concerned radioactive sources, but only 2% of them were related to HASS (according to the legal definition). Lost and found of sources in the considered timeframe represents the majority of incidents with radioactive sources. In four events, a HASS had been found which required intensive investigations. Fortunately, no exposure to people above the dose limits for occupational exposure was observed. Nevertheless, the frequency of radiological incidents with radioactive sources emphasizes the importance to enhance the regulatory infrastructure for the control of radioactive sources.

All incidents are recorded and analysed at a national level. A brief summary about the annually occurring incidents in Germany is published in annual reports, Umweltradioaktivität und Strahlenbelastungen, by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

4. THE GERMAN HASS REGISTER

A modern and reliable system for the tracking of HASS according to the HASS Directive has been established within the territory of Germany, which is a major contribution to enhance the safety and security of radioactive sources. The German HASS register is an electronic database, which has been on-line since 2006 (see Fig. 2). Efforts are necessary to ensure consistency and quality of data. Since its start, the software of the German register has been continually

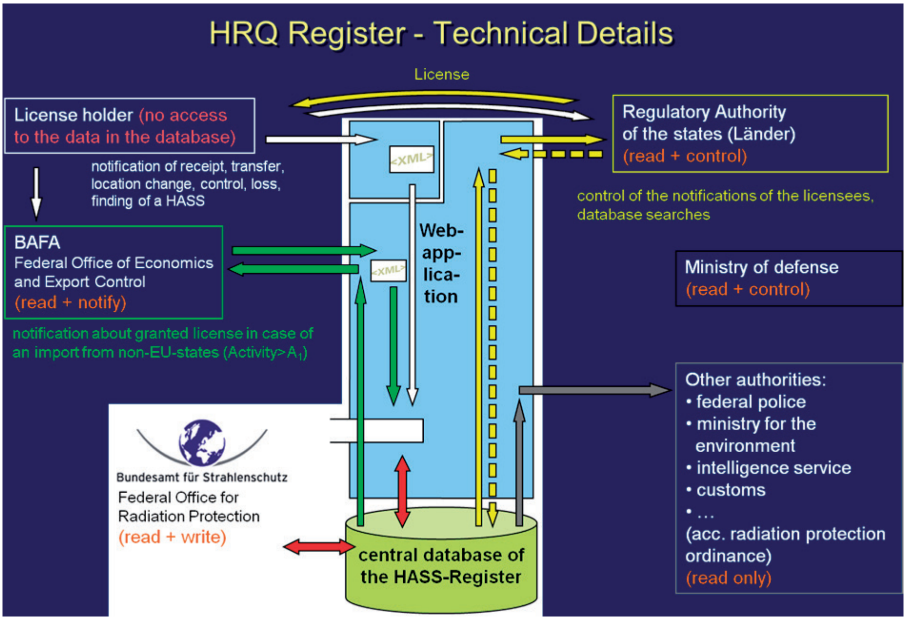

FIG. 2. Scheme of the German HASS register.

improved. The system runs very reliably. The data in the registry have to be kept for 30 years, which allows tracking over long periods.

The German HASS register manages the information exchange between licensees, competent Federal State authorities and the administration at the Federal Office for Radiation Protection. It allows Federal as well as local authorities to trace back high activity sources in Germany, and it helps to verify whether such a source is in compliance with their licensed use. Every licensee is obliged to send notifications about receipt, transfer, location change, control, loss, theft or finding of a HASS to the registry. The notifications need to contain the following data according to the European standard record sheet which is part of the German regulations:

— Licence holder (name and address);
— Licence (date of issue and limitation);
— HASS characteristics (identification number, nuclide, activity, physical and chemical properties, and manufacturer);
— Use and operational controls of the HASS;
— Location of the HASS;

- Leakage tests (once per year);
- Recipient or sender of the HASS if transferred.

The data are communicated only electronically via secure Internet connections. Separate web applications for licensees and authorities provide different connections to the database.

4.1. Tasks and access rights

Access to the registry for the different authorities and licensees according to the Federal system in Germany is granted on different levels and rights, depending on the different duties and responsibilities according to the Radiation Protection Ordinance (see also Fig. 2). Information on data in the registry can be given on request to other Federal State Police Authorities, Customs Authorities and Federal Intelligence Services and comparable international authorities to facilitate and to accelerate the investigation of criminal or malevolent acts.

4.2. Statistical data

Currently, more than 97 000 notifications on receipt, transfer, location change, loss and finding of 27 000 radioactive sources have been registered since the start of the on-line registry in 2006. The annual increase amounts to more than 10 000 notifications. Because of the Federal system in Germany, there are 60 competent authorities with access to the database for control purposes. By the end of 2012, the master data of 646 licensees had been gathered in the register.

Only about 40% of the 27 000 registered sources are still HASS sources according to the German Radiological Protection Ordinance because either their activity has decreased under the HASS limit (low half-life time) or the sources have been exported from Germany. As of July 2013, the register contained 11 100 HASS sources with 14 different radionuclides (see Fig. 3). The most frequently used nuclide in the HASS sources is ^{60}Co (48%), with a maximum activity of 2.2 PBq. Further nuclides used (in the order of frequency) are:

- Iridium-192 (22%) with a maximum activity of 39 PBq;
- Caesium-137 (14%) with a maximum activity of 44 PBq;
- Selenium-75 (10%) with a maximum activity of 3 PBq;
- Strontium-90 (3%) with a maximum activity of 1 PBq;
- Americium-241 (2%) with a maximum activity of 1 PBq (see Fig. 4).

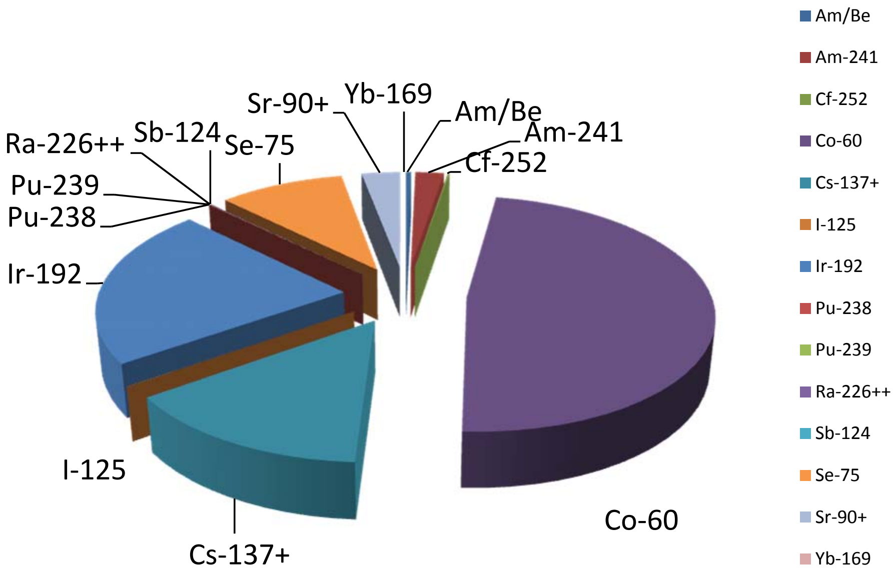

FIG. 3. Number of sources and radionuclides recorded in the German register as of July 2013.

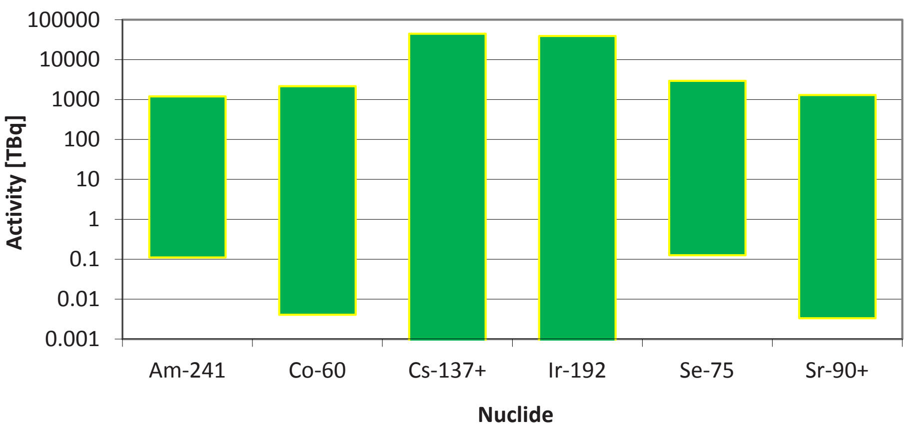

FIG. 4. Activity ranges of high activity sealed sources for selected radionuclides as of July 2013.

5. SECURITY OF OTHER RADIOACTIVE MATERIAL

At the Nuclear Security Summit in Washington, DC, 12–13 April 2010, Federal Chancellor Angela Merkel emphasized the importance of securing radioactive sources which are addressed in both the Summit Communiqué as well as the Work Plan. Her intervention was based on the fact that Germany pays strong attention to the security of radioactive material to minimize the likelihood of malicious use. Beyond that, a certain need is seen to achieve a minimum standard in protecting radioactive material worldwide.

In Germany, Federal and *Länder* authorities jointly monitor these sources consistently to ensure that they do not fall into the hands of non-authorized persons and — in the worst case scenario — are not used by terrorists (e.g. to assemble ‘dirty bombs’).

The Atomic Energy Act stipulates that everyone who intends to construct, operate or own a nuclear installation or wants to handle radioactive material needs a licence beforehand. Physical protection is a licensing prerequisite. Licences may only be issued if the necessary protection against malevolent acts or other illegal interference by third parties is ensured. The same prerequisite is required for licensing transport and storage of nuclear material and other radioactive material.

German competent authorities monitor adherence to the legal requirements. Preventing the illegal purchase and the misuse of such sources is of prime importance. However, securing radioactive sources and other radioactive material is to a certain extent impaired by the fact that in many cases people handling these sources (e.g. in a hospital) are well aware of their radioactive safety hazard but far less aware of the security risks involved. Therefore, it is an important task to enhance awareness for the security of radioactive sources.

5.1. Current practice

The competent authorities of the *Länder* substantiate the appropriate implementation of security measures within the licensing process for the use of other radioactive material. The main instrument to specify security measures is a technical standard for radiation, fire and theft protection (DIN 25422) which applies a graded approach on categorization of radioactive materials into four activity classes, based on the multiples of radionuclide exemption levels. Safety and security measures are defined for each activity class. As of today, radiological consequences such as the release of a substantial amount of radiation or radioactive material due to malicious acts and nuclear terrorism are generally not yet considered within the licensing process for handling and transport of other radioactive material.

5.2. The new approach

Germany has reassessed the radiological risks of other radioactive material, in particular with a view to their potential risk in the case of malicious use.

The main scope and challenge of this approach is to provide a comprehensive and consistent security regime for other radioactive material while still ensuring their usability.

This approach is based upon national legislation and is consistent with national nuclear security regulations for nuclear material. It regards international recommendations on security of radioactive sources [8, 9].

Within the context of a national threat assessment, particular challenges have been identified regarding alpha radiation emitting material, applications in the medical sector and the use of mobile devices containing radioactive sources.

5.3. Design basis threat

Since 2012, a draft of a national design basis threat (DBT) defines possible release scenarios and parameters of radiation and radioactive material due to malicious acts based upon the national threat assessment. It presumes basic technical skills and knowledge in nuclear physics of a potential offender and describes his auxiliary means. The DBT determines an effective dose of 100 mSv in case of the release of radiation or radioactive material as the general protection objective of the public and applies to sealed sources and other unsealed radioactive material.

5.4. Guideline

The main objective for recasting the security regime for other radioactive material is to compile a comprehensive guideline for the security during the use, storage and transport in Germany. According to IAEA Nuclear Security Series No. 11, Security of Radioactive Sources [8], the draft of the guideline applies a graded approach to categorize radioactive materials using three security levels based upon the potential radiological risk of the radioactive material. For each security level, graded requirements and measures have been determined.

Contrary to Ref. [8], no D-Values are used for the categorization of other radioactive material within the guideline's draft. For this purpose, specific security values for more than 100 radionuclides have been determined taking into account the radiological consequences of malicious acts and nuclear terrorism and regarding possible release scenarios and parameters as defined within the DBT.

6. OUTLOOK

With the revision of the European Basic Safety Standards, new challenges have to be met by EU Member States. The draft currently available presents a set of new requirements and introduces certain changes based on recent publications from the IAEA, the International Commission on Radiological Protection and the International Commission on Radiation Units and Measurements.

Following the draft, the HASS thresholds will be changed fundamentally, since these levels will be harmonized with the IAEA D-Value. This is an important step for the European Union to harmonize with internationally accepted risk levels. Apart from these new legal requirements, the German HASS register is to be revised in order to build a system with a large degree of automation to provide better user friendliness but always in consideration of necessary security requirements.

Strengthening the security regime for other radioactive material is an important future task in Germany. Therefore, a comprehensive guideline is currently being developed to provide appropriate security while still ensuring the usability of radioactive sources in Germany. This guideline represents an efficient instrument for enhancing the security of other radioactive material during the use, storage and transport in Germany. Securing radioactive material is to a certain extent impaired by the fact that in many cases people handling these sources are well aware of their radioactive safety hazard but far less aware of the security risks involved. An important task will be to enhance awareness for the security of radioactive sources especially regarding alpha radiation emitting material, applications in the medical sector and the use of mobile devices containing radioactive sources and at other less secure sites.

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PANEL 1

REGIONAL PARTNERSHIP AND ASSISTANCE, AND PEER REVIEWS

Chairperson: **F. Morris** (United States of America)

Rapporteur: **W. Rhodes** (United States of America)

IAEA-CN-204/140

IMPROVING REGULATORY BODIES' ACTIVITIES IN AFRICA THROUGH REGIONAL COOPERATION

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Abstract

The Forum of Nuclear Regulatory Bodies in Africa (FNRBA) is presented as a good regional platform that plays key role in assisting the establishment of regulatory bodies and in enhancing and sustaining their activities. The FNRBA is founded on the aspirations of its members and the lessons learned from other similar regulatory networks. To achieve its objectives, the FNRBA needs more partners to learn and enhance its activities effectively, and particularly in the domain of radioactive sources control. The FNRBA is open to all nuclear regulatory bodies in the region and is voluntary. This cooperation makes use of the triangular cooperation mechanism that involves advanced and less advanced countries working together with assistance from the IAEA and other partners in development.

1. INTRODUCTION

Radioactive sources have already caused a number of accidents with serious consequences to human beings and environment. The IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [1] and the Guidance on the Import and Export of Radioactive Sources [2] establishes basic principles applicable to the security of radioactive sources. According to these principles every State has (p. 6 of Ref. [3], original emphasis):

"— To take the appropriate measures necessary to ensure that radioactive sources are **'securely protected during their useful lives and at the end of their useful lives**' (paragraph 7 [of the Code of Conduct]);
— To emphasize 'to designers, manufacturers (both manufacturers of radioactive sources and manufacturers of devices in which radioactive sources are incorporated), suppliers and users and those managing disused sources **their responsibilities for the safety and security of radioactive sources**' (paragraph 15);

- To define 'its **domestic threat**, and **assess its vulnerability** with respect to this threat for the variety of sources used within its territory, based on the potential for loss of control and malicious acts involving one or more radioactive sources' (paragraph 16);
- To have legislation and regulations in place for 'requirements for **security measures to deter, detect, and delay** the unauthorized access to, or the theft, loss or unauthorized use or removal of radioactive sources during all stages of management' (paragraph 19);
- To ensure that 'the regulatory body established by its legislation has the authority to attach clear and unambiguous conditions to the authorizations issued by it ...' (paragraph 20);
- To ensure that its regulatory body has the authority to **require a security plan or assessment, as appropriate, and to promote the establishment of a security culture** among all individuals and in all bodies involved in the management of radioactive sources (paragraphs 20 and 22)."

In addition to these requirements, the revised IAEA Code of Conduct has incorporated the following points [4]:

- Establishing a national registry/inventory of radiation sources;
- Cradle to grave oversight of sources;
- National strategies for locating, identifying and regaining regulatory control over orphan sources;
- Strengthening control over the import and export of radioactive sources.

Although the responsibilities of States on the control of radioactive sources through their life cycle are precisely underlined [5], the cradle to grave oversight of sources is a global issue which requires appropriate measures at international, regional or subregional levels.

The Forum of Nuclear Regulatory Bodies in Africa (FNRBA) is seen as one promising regional initiative to deal with this concern. This presentation highlights the FNRBA activities and perspectives in this regard.

2. INVENTORY OF SOURCES AND USES

The FNRBA recommends to its members the establishment and maintenance of a national radioactive source registry. The level of the implementation of this recommendation is assessed during the annual plenary meeting of the Forum.

TABLE 1. SOURCE INVENTORY

Categories of sources	No. of sources	No. of States with sources	No. of States with legislation	No. of States with established regulatory bodies
Category 1	81	18	18	17
Category 2	>1928	19	19	18
Category 3	>2727	21	21	20

Twenty-six out of 33 members of the FNRBA provided their source inventory during the fourth plenary meeting, held in March 2009, in Yaoundé, Cameroon (see Table 1).

It was noted that three States lacked radiation safety legislation and four were without established regulatory bodies.

Sealed radioactive sources are mainly used in Africa for medical and industrial purposes. Around 60 cobalt machines are available on the continent for the treatment of cancer. Industrial applications include irradiation, gamma radiography, level and conveyor gauges well logging.

At its annual plenary meeting, the FNRBA evaluates the capacity of the members of the Forum to discharge their main regulatory function concerning authorizations, inspections and enforcement related to radioactive sources in their respective countries. The IAEA self-assessment tool is used to this end. The Radiation Safety Information Management System (RASIMS) information technology platform, developed by the IAEA, provides the status of the national infrastructure for radiation safety in different countries.

As of December 2012, only four States in Africa have ensured good progress in Thematic Safety Area 1 (TSA1) related to the establishment of the national infrastructure for radiation safety.

3. REGULATORY CHALLENGES RELATED TO THE CONTROL OF SOURCES IN AFRICA

— States with no legislation;
— States with legislation and no regulatory bodies;
— Regulatory bodies with variant performances;
— Legacy practices related to mining and other uses of radioactive sources;
— Free circulation of goods and people in subregions.

3.1. Legislation

More States have legislation but lack regulations and guidance. For those with regulations, the main issues are their completeness and consistency with international standards. Furthermore, many States have draft legislation awaiting promulgation.

3.2. Regulations and regulatory bodies

Many States have already issued legislation, but do not have a regulatory programme to implement the provisions of the law. There are Member States which do not have a regulatory body established by legislation. Others have a regulatory body established but are not operational. Some regulatory bodies formally created do not have the legal basis to exercise the powers of a regulatory body, or the capabilities and resources to perform their functions.

3.3. Staffing and training

Almost all States on the continent are facing the same issue of the availability of qualified staff to undertake the regulatory activities. Moreover, many of the existing regulatory bodies do not have a national strategy and programme for training of their staff, and this is considered as a major issue in Africa.

3.4. Funding of the regulatory body

Few States provide sufficient funding and resources for their regulatory bodies to fulfil all their regulatory activities.

3.5. Legacy practices

Legacy practices related to mining and other uses of radioactive sources have led to orphan sources of Categories 1–3. There is need to elaborate country strategies to search for and to safely manage orphan sources.

3.6. National sources registry

The national source registry is to be established and maintained in all States for effective control of radioactive sources.

4. FNRBA ACTIONS TO IMPROVE CONTROL OF SOURCES

4.1. Harmonization of regulatory activities in the Africa region

4.1.1. Sharing experience

Members of the Forum provide a country report on self-assessment of regulatory activities during the annual plenary meeting. Participants at this occasion interact and discuss problems encountered, and learn from successful solutions achieved.

Experiences from other regions presented by invited speakers complete this approach and enlarge the scope of the FNRBA plenary face to face meeting to discuss regional regulatory issues.

On discussions related to control of radioactive sources, the FNRBA was granted, at its fifth plenary meeting, held in Tunisia, in May 2013, by presentations from the United States Nuclear Regulatory Commission's Radiation Sources Regulatory Partnership on strengthening regulatory control over radiation sources, and from the IAEA on the status of radiation safety in Africa.

Another FNRBA mechanism to exchange experiences and to share information is provided by its web site developed under the IAEA Global Nuclear Safety and Security Network. This information technology platform is a meeting point for the members of the Forum and other external to exchange on radiation and nuclear regulatory issues.

4.1.2. Training of regulatory body staff

The FNRBA and its partners provide for number of training events each year on specific regulatory issues such as 'emergency preparedness'[1] or 'safety and regulation of radioactive sources'[2]. Trainees are proposed by FNRBA members and the event is hosted by the partner institution outside the region or by the FNRBA member.

4.1.3. Activities of thematic working groups

The FNRBA has established five thematic working groups (TWGs) on topics related to radioactive sources control:

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[1] See the Workshop on Emergency Preparedness and Environmental Radiation Monitoring, Daejeon, Republic of Korea, 17–28 September 2012.

[2] See FNRBA workshops on safety on regulations in Cape Town, South Africa, 5–16 November 2012.

(1) TWG1: Upgrading Legislative and Regulatory Infrastructure;
(2) TWG7: Upgrading of Security of Radioactive and Waste Safety Management Infrastructure;
(3) TWG8: Upgrading of Transport Safety;
(4) TWG9: Emergency Planning and Response
(5) TWG10: Nuclear Security.

The TWGs assess the regional needs and propose strategies and action plans to address them.

4.2. Implementation of IAEA regional projects

To improve the regulatory activities at the regional level, the FNRBA encourages its members to successfully implement IAEA technical cooperation projects related to radiation and nuclear safety. The IAEA Model Project on Upgrading Radiation Protection Infrastructure and the regional project on self-assessment (RAF9038) have very much contributed to promoting the establishment of national infrastructure for radiation safety in Africa. A number of other IAEA regional projects connected to FNRBA TWGs are being implemented by Member States.

5. FNRBA CHALLENGES

5.1. Networking

The FNRBA web site is a knowledge portal for the Forum and a communication platform with external parties. It is expected that individual regulatory body web sites will be connected to the main FNRBA portal to increase exchange of experiences among the members of the Forum.

Face to face during the plenary and the TWGs coordination meetings is a regional approach to promote human networking in the domain of radiation safety. Therefore, getting the maximum number of participants at these meeting becomes a challenge. Few members of the Forum are able to cover the transport fees to attend these events.

5.2. Partnership

The development of partnerships between the FNRBA and organizations with similar objectives is in progress. Good achievements have been registered in 2010 with memorandum of understanding signed by the FNRBA and the Korea

Institute of Nuclear Safety. Other formal collaborative agreements are expected to be concluded in forthcoming months. The FNRBA counts on such arrangements to increase the technical capacities of its members and their performance to accomplish the mandatory regulatory activities.

5.3. Funding

Few States provide sufficient funding and resources for their regulatory bodies to fulfil all their regulatory functions. Noting that nuclear industry in the Africa region is not developed, apart from South Africa, the FNRBA funding capacity is absolutely limited.

6. CONCLUSION

It is necessary to increase cooperation and exchange between regulatory bodies for radiation safety and partners to promote regional framework for control of radioactive sources during their useful life and after. In this regard, harmonization of national legislations and regulations is to be included into regional network strategies. A regional capacity building approach aiming at gradually increasing the expertise of regulatory bodies for radiation safety in the region needs to be developed and strengthened.

The FNRBA is developing cooperation and partnership to improve the control of radioactive sources in Africa, including search and securing orphan sources, promotion of safety culture, emergency preparedness and response, and combating illicit trafficking of radioactive materials.

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INTERNATIONAL COOPERATION ON RADIOACTIVE SOURCE SECURITY IN SOUTH EAST ASIA

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Abstract

The paper describes international technical cooperation and assistance in South East Asia on the establishment, implementation, maintenance and sustainability of radioactive source security measures for the prevention of unauthorized acquisition of, or access to, high activity radioactive sources.

1. THE NEED

There is broad recognition of the need to ensure the effective protection and control of radioactive sources and their associated facilities. Since the terrorist events of September 2001, this recognition now includes a greater appreciation of the threat that radioactive sources and their associated facilities could be used in malicious acts intended to cause damage, disruption or other adverse consequences to the political, social, economic, health, and environmental infrastructure and well-being of communities. As of September 2013, the national commitments of 119 States to the international Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1], and related expressions of commitment given at the Nuclear Security Summit in Seoul, in March 2012, provide an international benchmark and demonstration of willingness to act to counter the threat of radiological terrorism [2–5]. Although encouraging, such commitments are just the start — the real work lies in the practical and sustained implementation of these commitments wherever high activity radioactive sources are present [6]. Simply put, for radioactive sources that pose a significant risk or are categorised as dangerous, national commitments require the need for physical protection and security management of those sources and their associated facilities **in addition** to the protection of personnel and the environment required by customary radiation protection.

For many developing countries, this requires international technical cooperation and assistance to readily address implementation challenges and to ensure the application of security is timely, effective and consistent with relevant international recommendations and guidance for radioactive source security given in the IAEA Nuclear Security Series [7–9]. Such assistance is intended to provide capacity building with appropriate technical and resource support that draws upon related experience and lessons learned from assistance and implementation in other countries. Noting the objectives of the Code to achieve and maintain a high level of safety and security of radioactive sources, implementation of national commitments to properly secure high activity, dangerous radioactive sources needs to be a priority to ensure their continued controlled and peaceful use in medicine, industry, agriculture, mining, and research.

However, radioactive source security can present unique challenges due to the variety, location and circumstances of the use, transport and storage of high activity sealed sources [10]. Therefore, considerable effort may be needed by any State holding even a few such sources to ensure that appropriate physical protection and security management measures are: firstly, recognized as necessary; secondly, required by national regulations consistent with international standards and guidance; and finally, effectively and sustainably implemented. International assistance and cooperation provides an opportunity to promote recognition of the need, and the development of requirements, for radioactive source security. Further, it can assist regulatory authorities and operators to identify and address implementation challenges that may not necessarily be met if a State is solely reliant on its own capacity and internal resources, notwithstanding the recognition and commitment of individual professionals within a country. This is particularly the case for some States whose regulatory control and safety infrastructure capacity are not yet mature and therefore require further development to properly satisfy their commitment to the Code, including for basic control and radiation safety as well as for security. Whilst focused on security, the international cooperation and assistance programmes can in these cases provide a useful catalyst for progressing national developments concerning basic legislative and regulatory infrastructure that supports both safety and security. This is also sometimes the case for States with effective radiation safety and regulatory controls which are using the impetus of nuclear security (among other motivators) to overhaul or update their existing legislation and regulatory infrastructure.

The value of international cooperation and assistance on radioactive source security is recognized in para. 5(a) of the Code, in that the Code's objectives can be met through the fostering of international cooperation. Further, whilst recognizing that each State carries the full responsibility for nuclear security, one of the essential elements of the IAEA Nuclear Security Fundamentals is international cooperation and assistance [9]. Its Essential Element 6 (para. 3.6 of Ref. [9]) specifically requires:

(a) Designating points of contact similar to those in the Code;
(b) Providing timely information on relevant acts and threats;
(c) Timely response or support to recover and protect materials;
(d) Providing generally for cooperating and exchanging experiences and information, including on the establishment, implementation, maintenance and sustainability of a State's nuclear security regime;
(e) Proper protection of sensitive information.

This paper describes international technical cooperation and assistance in South East Asia provided under item (d) above — the establishment, implementation, maintenance and sustainability of radioactive source security measures for the prevention of unauthorized acquisition of, or access to, high activity radioactive sources in use, storage or transport.

A significant part of any State's nuclear security regime needs to be directed to measures for preventing malicious use or other unauthorized acts involving radioactive sources and their associated facilities. This is primarily achieved by ensuring the effective control and protection of radioactive sources throughout their life cycle. In terms of the topical priority of international assistance efforts, given the extent of activities involving the use, storage or transport of high risk radioactive sources in all countries, then the focus on prevention involving these activities is at least an equal priority to the effort devoted to detection and response measures, which are generally aimed at materials affected by some loss of control. Other aspects of international technical cooperation and assistance in South East Asia involving detection and response measures, or the preparedness to respond to or to mitigate the consequences of malicious use, are described elsewhere.[1]

2. THE PARTNERSHIP

Since 2004, the international programmes of the Australian Regional Security of Radioactive Sources (RSRS) Project and the United States Department of Energy's National Nuclear Security Administration's Global Threat Reduction Initiative (GTRI), primarily through Pacific Northwest National Laboratory, have supported the national development and implementation of physical protection

[1] See Ref. [11] and IAEA-CN-204/145, in Session 7, pp. 541–557.

and security management measures for radioactive sources and their associated facilities in South East Asian States [12–16]. Together with the IAEA, this effort has been recognized as the South East Asia Regional Radiological Security Partnership (see section H.4 of Ref. [17]). This assistance relies on using or adapting the relatively new measures for radioactive source security contained in the Code and the relevant IAEA recommendations and guidance, along with modifying or contextualizing the long standing principles and practices of physical protection applying to nuclear material. This international cooperation has served to ensure that the States involved are able to expeditiously implement applicable source security measures for the protection of primarily Category 1 and 2 radioactive sources and associated facilities during use, storage and transport.

A number of South East Asian States had improved and benchmarked their regulatory control and radiation protection infrastructure via the IAEA in activities such as the ‘Model Project’, which ran until about 2003, and various peer review missions [18]. For these States, this groundwork has better enabled the development and integration of source security measures from within an established regulatory framework, albeit young in some cases. Most of the partnership’s implementation activities have occurred in countries with this foundation in place and with the most Category 1 radioactive sources, such as Indonesia, the Philippines, Thailand and Viet Nam. Brunei Darussalam, Malaysia and Singapore have smaller inventories of Category 1 sources and have cooperated in some direct and regional activities specifically covering the prevention objectives of the cooperation. Cooperation with Cambodia and the Lao People’s Democratic Republic has mainly focused on providing information and awareness of the issues, as their basic regulatory infrastructure still needs to be established, although some protection of source facilities has occurred in Cambodia. Since May 2013, Myanmar has been actively engaged in direct activities. All ten South East Asian States have participated in regional review and topical meetings.

Participating State agencies primarily include regulatory bodies and national nuclear operators in their role as either or both a radioactive source facility licensee and a technical support organization for services and training. Typically via the regulatory body, at least Category 1 source facilities’ operating personnel are engaged in cooperation on physical protection implementation, training and the development of security plans. Other government departments and agencies also become recognized cooperation partners, often initially via awareness seminars and training courses. Cooperative activities are undertaken according to an analysis of the situation and the need for further development of a State’s radiation control, safety and security framework, the level of use of radioactive materials, and other relevant international cooperation that supports radioactive source security. Ongoing needs analyses are regularly performed with the participating State's experts and explicit recognition of their resources, constraints, and local conditions and practices. Action plans are mutually developed and implemented via training and workshop programmes with defined expectations, schedules and outputs. The systematic approach to training is applied to the cooperative activities involving training and training programme development. This significantly assists in producing and transferring the requisite knowledge, skills and experience, and promotes indigenous sustainability of the measures. The approach to assistance is focused on needs based technical engagement intended to develop measures that are more relevant and sustainable than those substantially imported.

3. ACTIVITIES AND OUTCOMES

The international assistance partnership in South East Asia has conducted over 250 national and regional activities since 2004, with at least 75% of these focused on prevention involving both regulatory and operator roles and responsibilities. The main types of activities include:

- The development, implementation and updating of regulatory requirements and guidance for radioactive source security.
- The installation by the US GTRI programme of physical protection upgrades at Category 1 source medical and industrial facilities.[2]
- The development and conduct of seminars and training courses on the physical protection and security management of radioactive sources, for senior officials, regulators and operators.
- Following the delivery of training courses, conducting training development workshops allowing for the adaptation and transfer of knowledge and methods, typically to the regulatory body's or national nuclear agency's training group, to support local training.
- Workshops covering the development, review and implementation of facility security plans for the operational integration of physical protection measures with security management, and in demonstrating regulatory compliance.
- Training and support for improving regulatory capabilities in assessment and inspection for security.

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[2] These US GTRI activities include assessment and installation of physical protection equipment and systems at these facilities. They are not included in the count of national and regional activities conducted.

Some of these activities have been reported at previous Code technical meetings on information sharing in 2007 and 2010, with specific reference to the relevant provisions of the Code [19–20]. The following sections highlight activities and outcomes on regulatory infrastructure development, training and training development due to their foundational status in promoting and implementing a State's radioactive source security programme. A description is also provided of the role and value of regional review meetings, and on how an international technical assistance partnership can provide for a greater appreciation of the requirements for the systematic integration of security measures to ensure commitments become practical, effective and sustained.

3.1. Regulations

Other than very general provisions, regulations or guidance specifically addressing radioactive source security was not available prior to the current Code, the 2004 IAEA-TECDOC-1355 [21] (now superseded) and the 2009 IAEA Nuclear Security Series No. 11 [7]. The assistance provided by the Partnership to regulatory bodies to develop, implement and update the requirements and guidance for radioactive source security typically includes establishing working groups to develop a thorough regulatory motivation and knowledge of the source security requirements based on the IAEA guidance or model regulations, and then producing specific source security regulations or guidance materials. Generally, a peer review occurs during the working group process to ensure regulations or guidance are effective, practical, complete and conform to the regulatory body's other regulations and regulatory approach. This has resulted in the Code of Philippines Regulations part 26, originally developed in 2007 based on IAEA-TECDOC-1355 and updated in 2013 to incorporate IAEA Nuclear Security Series No. 11; in Viet Nam, the Vietnam Agency for Radiation and Nuclear Safety (VARANS) Circular 08/2010/TT-BKHCN in 2010; and in Indonesia, the Nuclear Energy Regulatory Agency (BAPETEN, Badan Pengawas Tenaga Nuklir) Chairman's Regulation 07/2007. Some peer review and workshop activities have been conducted for Malaysia and Thailand; however, the completion of their source security regulations is awaiting the overhaul and promulgation of their umbrella nuclear legislation and regulations governing such matters.

3.2. Training development

Knowledge about radioactive source security measures is relatively new compared with the equivalent body of knowledge and practice for radiation protection. Integral to developing a sound national regulatory basis, and to ensuring the effectiveness and sustainability of the results of this international technical assistance, is the development of local practical knowledge, typically via training and training development. Since 2005, the Partnership has developed and regularly delivered a course on the Physical Protection and Security Management of Radioactive Sources at Security Level A Facilities (PP&SM) for both regulators and operators. In addition to the full PP&SM course, the Partnership has also regularly delivered a half-day national awareness seminar for senior government officials, decision makers, regulators and managers from high activity radioactive source facilities to cultivate the motivation to address radioactive source security at senior levels of relevant national stakeholders, particularly given the challenges and uniqueness of applying security to radioactive source practices [10]. The methods of the systematic approach to training have been applied in developing and delivering the PP&SM course, details of which were reported in the July 2013 International Conference on Nuclear Security and elsewhere [22–23].

However, the Partnership recognized that it is not sufficient in terms of national effectiveness and sustainability to provide a periodic PP&SM training course or seminar delivered by international experts. What is required is the timely transfer of the practical knowledge and methods so that the relevant national agencies can develop and deliver their own PP&SM training course locally on a more frequent basis. As a result, a Training Development Workshop (TDW), sometimes referred to as a 'train the trainer' programme, was developed and implemented. The TDW is designed for a small group from the national regulatory body, or the main nuclear operating agency with responsibility for training, to review the international PP&SM course materials and then to adapt, modify and develop a national course programme that includes their own syllabus, content, lesson plans and associated materials. Prerequisites for TDW participation include:

(a) The national source security regulations to be in place or well developed in draft;
(b) Prior participation in the internationally delivered PP&SM course and familiarity with all topics covered in that course;
(c) Some assignment of individuals to become subject matter experts on the topics covered;
(d) Some knowledge of their State's Security Level A facilities and their operation, including knowledge of the roles and responsibilities of relevant staff.

Each TDW uses the systematic approach to training as a basis for the PP&SM course design, development and delivery, and conducts a training needs analysis:

- To identify the relevant local factors affecting security of the facilities and their operation;
- To identify and define target audiences;
- To define the course objectives and each topic's learning outcomes.

Specific further technical tuition may be given during the workshop. At the end of each TDW, participants have developed their PP&SM syllabus and some of the content of lecture and exercise modules and their associated learning outcomes and session strategies or lesson plans. This then enables workshop participants to further develop and finalize their course over the subsequent months and then deliver the training to relevant regulatory and operator staff, sometimes with the Partnership's international experts as observers and reviewers of the national course delivery. The success of the TDW model is demonstrated through the source security cooperation with Indonesia's National Nuclear Energy Agency (BATAN, Badan Tenaga Nuklir Nasional), the Philippine Nuclear Research Institute (PNRI) and VARANS, with each of these agencies now developing and delivering their own training programmes for Security Level A facilities. The PP&SM training and training development progress in Indonesia by BATAN is being reported at this conference.[3]

3.3. Regional reviews

An important feature of the Partnership's arrangements is creating the opportunity to periodically and formally review progress and, in so doing, to identify additional needs and challenges that may have arisen from prior implementation activities. The international cooperation effort has held three regional review meetings: in Indonesia in July 2008, in Viet Nam in March 2010, and the Philippines in January 2012, with a fourth meeting to be hosted by Thailand in February 2014 and supported fully by the US GTRI.[4] These reviews explicitly provide a means of practical knowledge exchange for improving and normalizing the approach to, and understanding of, radioactive source security. These meetings' outcomes affirm the importance of a cooperative approach and

[3] See IAEA-CN-204/220, Panel 2, Session 3, pp. 259–248.

[4] The reports of the South East Asia Regional Review Meetings for July 2008, March 2010 and January 2012 are available at: http://www.ansto.gov.au/BusinessServices/RegionalSecurityofRadioactiveSourcesProject/index.htm#reviewmeetings.

the value of international technical assistance within the region. The attributes of the cooperative approach contributing to productive outcomes in South East Asia that are evident from these review meetings include:

(a) A regional scope and focus involving all States and relevant agencies that generates a shared commitment to meeting the objectives of radioactive source security — no State is ‘going it alone’, although each State has different needs and interests.
(b) A focal programme from a donor State in, or close to, the region which fosters an attitude of ‘looking after our neighbourhood’ and ‘act locally, think globally’. The Australian RSRS Project served this purpose with support from, and alignment with, the US GTRI programme.
(c) Attentive use of planning, needs analysis and systematic methods, consistently but flexibly applied.
(d) Attention to regulatory and operator agency level resourcing and sustainability issues, each of which require recognition of what a national commitment involves.
(e) The sharing of best practices and adaptation of methods based on regular review and topical meetings.

The cultivation of such attributes by the international assistance partnership in South East Asia ensures a shared commitment to international cooperation and mutual understanding by all partners to effectively apply practical standards for radioactive source security. This then fosters good security culture in practice.

Finally, the partnership has supported regional topical events including a first of a kind workshop to address Security Level B measures in industrial radiography in Sydney in September 2010, and a second regional workshop hosted by Malaysia in December 2012 which was supported by the Government of Canada’s Global Partnership Program and is the subject of a poster paper at this conference [24].

3.4. Integration

One outcome of regular reviews under the Partnership is the recognition of the need for a systematic approach that integrates all prevention measures: not only for the delivery of international technical assistance, but especially for the integration of measures at all levels of the State, namely the national government, the radiation regulatory body and other government agencies and operating organizations. A greater appreciation of the requirements for the systematic integration of source security measures by all concerned is necessary to ensure commitments become practical, effective and sustained. This appreciation is needed, as radioactive source security is still novel and not the same in application as the more mature security of nuclear material and nuclear facilities. Whilst an effective State nuclear security regime for radioactive sources can build on existing basic radiation regulatory and safety measures, there are factors in the use, storage and transport of radioactive sources that make security distinctly challenging, as described at the July 2013 IAEA International Conference on Nuclear Security [9]. In addressing these challenges, an integrated combination of steps is required to ensure that all responsible organizations have the necessary motivation, knowledge, and resources to establish or strengthen, implement and sustain nuclear security regimes for radioactive sources. Further work is required by the IAEA and the international community to develop a practical general model of this integration and the roles and relationships among the national government, regulatory body and operators to ensure effective and sustained radioactive source security. A model of the roles and responsibilities of a State's nuclear security regime for radioactive sources is presented in Fig. 1.

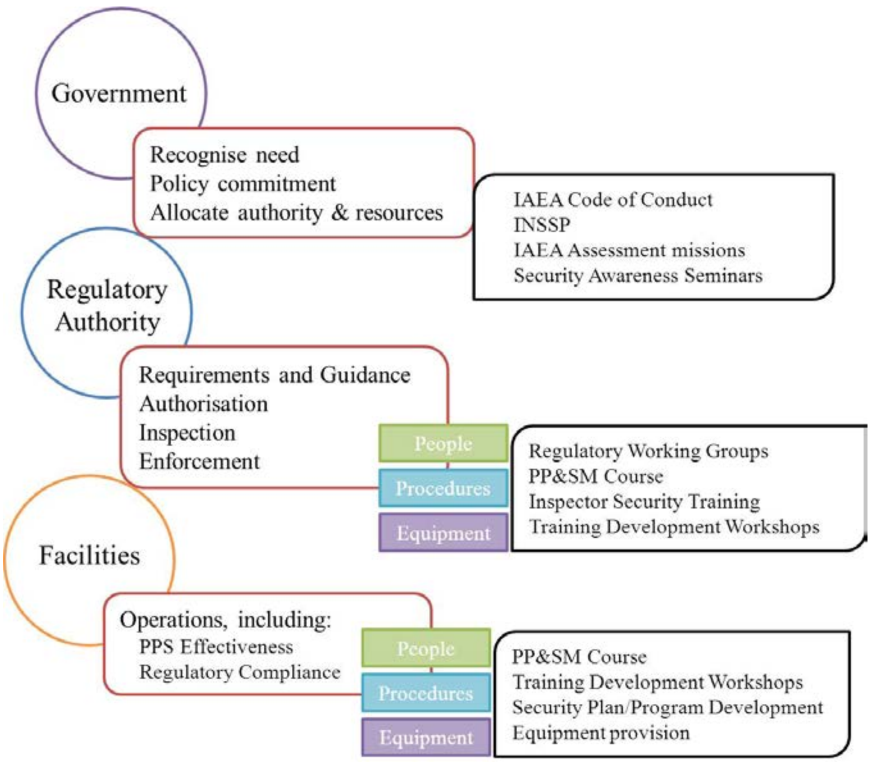

FIG. 1. A model of the roles and responsibilities of a State's nuclear security regime for radioactive sources.

4. CONCLUSIONS

The international radioactive source security cooperation and technical assistance efforts in South East Asia have achieved:

— Significant levels of implementation of radioactive source security regulatory requirements and of facility protection and security management measures designed for protection of sources;
— Progress towards the sustainable development and implementation of national training programmes for radioactive source security;
— Enhanced local capabilities to ensure prevention measures are effective, systematic and well integrated across the range of affected stakeholders.

By any measure, the regional partnership has made a difference in the timely and effective practical application of protection measures for dangerous radioactive sources and their associated facilities in many countries. The Partnership's approach and activities have:

— Developed and strengthened national, bilateral and regional networks affecting nuclear security, safety and emergency response;
— Matured a common understanding, consensus and a shared sense of commitment to the current and future challenges of practical radioactive source security;
— Created attitudes promoting good security culture via the sharing of best practices, programme development and implementation insights;
— Fostered recognition of the need for further development of regulations, policies, procedures, guidance and practices of local, national, and international authorities, organizations and companies, and their integration.

These outcomes all impact on prevention effectiveness, and the organizational safety and security cultures, as well as the implementation and further development of relevant international norms and methods to enhance the security of radioactive sources.

Finally, some observations generated through this international cooperation on radioactive source security in South East Asia include:

(a) There remains an ongoing need to raise and maintain awareness of the need to protect and control radioactive sources from a security viewpoint.
(b) The importance of national commitments to the security of sources remains. Such national commitments, however, need to be put into effective and sustained practice.

(c) The development and implementation of that national commitment, at both policy and technical levels, requires recognition of the human, financial, and technical resources, as well as recognition of the consequences of not making such a commitment.
(d) The development and effective delivery of a national source security programme requires a systematic approach to develop, or build on existing, foundational radiation control and safety measures. The significant elements of this approach require:
    — Regulating for source security through establishing security requirements and related authorization, inspection and enforcement provisions;
    — Implementation of physical protection and security management measures by operators;
    — National training programmes and ongoing professional development for regulators and operators;
    — Measures to prevent and mitigate the consequences of security breaches, including malicious acts;
    — Institutionalizing radioactive source security at the national, regulatory authority and operator levels so that it is not substantively dependent on ongoing international assistance programmes or individual professional champions.
(e) The importance of ongoing needs identification and assessment that values external peer advice and review, and gathering feedback and reviewing outcomes. This process assists to establish, implement, systematise, integrate, and improve source security programmes.
(f) The international cooperation and technical assistance programmes provide capacity building to ensure consistent, appropriate and effective application of source security measures based on IAEA guidance, and the identification and development of further measures and support.

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IAEA-CN-204/115

JOINT ACTIONS OF THE REPUBLIC OF TAJIKISTAN AND THE UNITED STATES OF AMERICA IN THE FIELD OF WEAPONS OF MASS DESTRUCTION NON-PROLIFERATION

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Abstract

The paper describes the legislative basis in the field of radiation safety and security and regulatory authority establishment in Tajikistan. Joint actions undertaken after the civil war in Tajikistan by regulatory authorities of the Governments of the United States of America and Tajikistan are presented. Actions performed and planned in order to prevent proliferation of weapons of mass destruction in Tajikistan are presented.

1. JOINT ACTIONS IN THE FIELD OF WEAPONS OF MASS DESTRUCTION NON-PROLIFERATION

After the declaration of independence, Tajikistan became a sovereign member of the world community and carried out reforms on the formation of democratic government. Tajikistan started to cooperate with international organizations such as the European Union, the IAEA, the International Monetary Fund, the United Nations, the United Nations Educational, Scientific and Cultural Organization, the World Health Organization and others in social and economic fields. After the declaration of independence, a number of States started to cooperate with Tajikistan on a bilateral basis.

The first steps of Tajikistan towards independence were complicated after experiencing a civil war (1992–1997). The civil war destroyed many infrastructures, including services ensuring the radiation protection of the population and the environment.

In 2003, under the Tajikistan Academy of Sciences, the Nuclear and Radiation Safety Agency (NRSA) was established. According to the Tajikistan Act “On radiation protection” (No. 42 from 1 August 2003), the NRSA is the State regulatory authority and officially assigned to cooperate with the IAEA and donor States in the field of ensuring nuclear and radiation safety of the population and the environment.

Due to Tajikistan joining the IAEA, signing the Treaty on the Non-Proliferation of Nuclear Weapons, the safeguards agreement, additional protocol to the safeguards agreement, and ratifying many conventions and agreements in the field of ensuring nuclear and radiation safety and peaceful use of atomic energy, the State started to receive assistance in establishing and strengthening its infrastructure in this field.

In close cooperation with the IAEA during recent years, a number of projects have been implemented on the establishment of legislative basis, information service, upgrading radiotherapy and nuclear medicine services, soil sciences, uranium industry wastes management, and specialists' preparation and training, among others.

Tajikistan is not a nuclear State, but currently sources of ionizing radiation (SIR) are widely used in medicine, industry, scientific and research areas, agricultural sectors and other fields. One of the key issues of ensuring safe use, storage and transportation of radioactive sources and their non-proliferation is the establishment of a State SIR database and carrying out its account and control. In this field, Tajikistan has received appreciable assistance from the United States Department of Energy (DOE) and the United States Nuclear Regulatory Commission (NRC). Starting from 2003, projects on ensuring intruder alarm and physical protection of sites with high radioactive sources have been implemented in Tajikistan. In the framework of this cooperation, the intruder alarms were installed in the Republican Waste Disposal Site (RWDS, Faizabad region), the Scientific Centre of Oncology under the Ministry of Health and the gamma laboratory of Tajik National University. Extensive repairs were carried out in Building No. 20 of the RWDS, where worked-out radioactive sources are disposed with a total activity more than 80 kCi and the gamma laboratory building of Tajik National University. Concrete block fences were constructed in vulnerable places around the RWDS high security zone.

In all these sites, the physical protection elements are installed in accordance with international requirements. Those elements includes video surveillance, a 24 hour record of all events in controlled premises and sites in the database, motion detectors for notification of guard personnel about intruder penetration and doors with dual lock according to two keys, among other things.

Especially, we would like to emphasize assistance from the DOE in carrying out orphan sources search. Search of orphan sources in northern Tajikistan is completed and currently the searches are carried out in southern Tajikistan. Under this project, two training courses were conducted, necessary equipment for searches realization were provided and the 'Niva-Shevrolet' vehicle was provided through an IAEA regional project with the purpose of orphan sources search to the Committee of Emergency Situation and Civil Defense under the Government of Tajikistan. The search of orphan sources is carried out by representatives of the Committee of Emergency Situation and Civil Defense, the Ministry of Interior Affairs and the Border Services of Tajikistan together with NRSA inspectors. Following a search of northern Tajikistan, more than 500 orphan sources and sources kept in storages not corresponding to radiation safety norms were revealed, which subsequently were transported and disposed in the RWDS.

Cooperation with the NRC is also successfully taking place. According to the agreement between the NRC and the NRSA, three projects are being implemented in Tajikistan:

(1) Inventory and establishment of the SIR database in Tajikistan;
(2) Introduction of amendments and additions to the Laws “On radiation safety” and “On licensing of separate kinds of activities”;
(3) Development of regulatory requirements for physical security.

In 2007, the NRSA, together with NRC support (an agreement between the NRSA and the company AdSTM Inc.) started to establish a national SIR database. The establishment of a national database meant inspection of existing data on SIR availability in organizations by NRSA representatives by means of conducting inventory inspections and inputting checked information into RASOD database according to requirements. We would like to mention that sealed radioactive sources, unsealed radioactive sources, ionizing radiation generators and associated facilities were referred as SIR.

Inspectors of the NRSA, NRSA branches, SE “Vostokredmet”, the Dushanbe sanitary epidemiological station and others participated in the inventory process. Following 250 organizations inspected, 1976 SIR were registered. Of them, 1130 were sealed sources, 35 unsealed sources, 811 generators and 110 associated facilities of SIR.

Of 1130 sealed sources, 774 sources were disposed in the RWDS and 356 sources are in operation, including 62 sealed sources of Category 1 and 2 sources, which are used in medicine and science research laboratories.

Amendments and additions to the Tajikistan Law “On licensing of separate kinds of activities” were introduced by the help of the project Introducing Amendments and Additions to the Law on Licensing. After long consultations with experts and harmonization with relevant authorities and ministries, it was adopted by the lower chamber of parliament. Currently, the regulation is prepared on the basis of this law and in nearest future will be submitted to the Government for approval.

Amendments and additions to the Tajikistan Law “On radiation protection” were introduced, discussed with experts and after harmonization with relevant authorities and ministries will be submitted to the lower chamber of parliament for approval.

Together with the NRC, discussions are currently underway on the issues of further SIR database modernization, improving and preparation of some legislative documents, strengthening resource and technical infrastructure of NRSA, and we always find good mutual understanding.

IAEA-CN-204/185

LEBANESE EFFORTS FOR A GOOD IMPLEMENTATION OF THE SAFETY AND SECURITY MEASURES FOR RADIOACTIVE SOURCES

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Abstract

The Lebanese Atomic Energy Commission (LAEC), the regulatory authority, is pursuing a continuous effort to establish an acceptable nuclear security level inside the country and on the borders in order to satisfy and fulfil the related international conventions and resolutions, as well as to be protected against any malicious act or even any unintentional incident involving radioactive or nuclear materials. In this perspective, the management of radioactive sources, combating nuclear illicit trafficking, physical protection and repatriate of the radioactive sources, nuclear materials accountancy and the installation of radiation portal monitors at different locations in Lebanon have been the main tasks achieved. Furthermore, a temporary radioactive waste store is prepared at LAEC premises for safe and secure storage of orphan sources, seized mainly in scrap activities.

1. INTRODUCTION

Lebanon is a member of many international binding instruments related to safety and security of radioactive sources and safeguards. Conventions and treaties have already been ratified or signed such as:

— Treaty on the Non-Proliferation of Nuclear Weapons;
— Small quantities protocol;
— Convention on Nuclear Safety;
— Early Notification and Assistance Conventions;
— Convention on the Physical Protection of Nuclear Material and its amendment;
— Vienna Convention on Civil Liability for Nuclear Damage and its amendment;

— Political commitment on the Code of Conduct on the Safety and Security of Radioactive Sources.

Despite the lack of national legal instruments that regulates the legal framework of nuclear and radioactive activities in Lebanon, the LAEC was assigned years ago by the Lebanese Government as the regulatory authority for safety and security of radioactive materials and sources, supported legally by a government decrees. Following an IAEA Integrated Regulatory Review Service mission, the necessary preparation of a nuclear law in Lebanon was launched and an IAEA reviewed copy is ready to be submitted to parliament for promulgation.

The LAEC has already established an inventory on the number, activity, location, status, type and use of radioactive and nuclear materials in Lebanon. They are mainly located in hospitals, industries and universities. Furthermore, the LAEC is in charge of all aspects related to nuclear safety, such as licensing, inspection, quality control, issuing regulations on good and best practices, control of public and workers dose, and personal dosimetry, among others. In addition, following a mission by the IAEA and the International Nuclear Security Advisory Service in May 2006, a nuclear security support plan was prepared which includes improvement of the regulatory legislation, assessment and recommendation concerning the vulnerability of some radioactive sources Categories 1 and 2, human resources development and the appropriate equipment for detection. In fact, the LAEC — in close cooperation with other national stakeholders — is pursuing a continuous effort to establish good management and control of radioactive sources during their life cycle. Some necessary actions were implemented and others are still being pursued in order to prevent, deter and detect any illegal movement, premeditated or accidental, of radioactive or nuclear materials.

2. REPATRIATION AND PHYSICAL PROTECTION

From 2009 to 2010, 37 cobalt sources were dismantled and repatriated: 36 from the Agriculture Research Institute, which was used for the sterilization of Mediterranean fruit fly, and one radiotherapy cobalt unit from the American University of Beirut Medical Center (see Fig. 1). To prevent any theft or sabotage, two medical centres have undertaken the necessary steps for the implementation of a reliable system of physical protection of Category 1 radioactive sources. Other hospitals are in ongoing similar process, within missions supported by and in cooperation with the IAEA, to dismantle and repatriate their sources, mainly Categories 1 and 2. In addition, special attention should be given to some sources which are located at certain cement industries.

FIG. 1. The two missions already completed to repatriate 37 cobalt radioactive sources.

3. RADIATION PORTAL MONITORS

Several radiation portal monitors have been installed at all Lebanese borders, Beirut international airport of Beirut and the seaports of Beirut and Tripoli. In this way, more than 90% of the commercial exchange activities between Lebanon and other countries are covered. These portals are operated by Lebanese Customs in cooperation with the LAEC as MEST. In case of real alarm, the LAEC will intercede for further investigations, and sometimes analysis will be done at LAEC laboratories for more accurate measurements. Furthermore, the Customs and LAEC staff will be equipped with portable detectors and will work together closely.

4. ACCOUNTANCY OF NUCLEAR MATERIALS

Nuclear materials, mainly depleted uranium, are located in different Lebanese areas, and are accounted and reported to the IAEA. The largest amount of the existing depleted uranium is used as shielding for radiotherapy sources.

5. ILLICIT TRAFFICKING

Within the illicit trafficking database, more than 100 incidents have been reported since 2007, and they mainly concern unauthorized disposal that are involved in scrap activities (see Fig. 2). The involved materials, mostly radioactively contaminated objects and sometimes radioactive sources, are seized and stored in a temporary storage at LAEC premises (see Fig. 3), they can be summarized as following:

(a) The radioactively contaminated scrap involved primarily ^{226}Ra, where the measured dose rate was in the range of 0.14–14 µSv/h on the surface of the located objects such as military scrap pieces, clocks, pipes, cylinders, metal discs and powders, among other things.

FIG. 2. Caesium-137 source and its shielding (2nd left), used as radiometric density measurement, found in routine inspection at scrap yards. Other sources or contaminated materials are seized as well during scrap export control at seaports.

FIG. 3. Orphan sources, involved in nuclear illicit trafficking, are isolated, transported, wrapped, shielded and stored at LAEC temporary storage of radioactive waste.

(b) Other incidents were related to sealed radioactive sources such as ^{241}Am, ^{60}Co, ^{137}Cs and ^{90}Sr. Figure 2 shows a metal container (jar shaped) which is shielding a capsulated caesium source with a current activity of 18 mCi. The shielding lead has a broken identification metal tag with information on the source. It is clearly stated a ^{137}Cs source of 30 mCi of activity, dated from 1984, and it has the label of the company name. After further analysis and investigations, it was found that the source, intended to be exported as regular scrap, was used as a radiometric density measurement in a local cement company. The necessary actions were carried out in order to ensure the security and the safety of the source. Moreover, the company has pledged to not repeat this serious incident resulting from negligence.

(c) Finally, some other seizures were concerned with nuclear material, such as depleted uranium or ^{232}Th.

Most the materials involved in the different incidents are of unknown origin, so they are temporary stored in a safe location at the LAEC until the founding of permanent national storage.

6. CONCLUSION

There has recently been an increasing number of radioactive incidents encountered in the scrap activities. In addition, there are growing efforts from the international community, through the IAEA and the United Nations Security Council, to combat nuclear illicit trafficking, as a major concern is that nuclear and other radioactive material could be used for malicious purposes. Furthermore, a deficit in the security measures has been reported for radioactive sources which are used in radiotherapy machines, irradiators and industrial radiography and gauges. The traceability and periodical control of radioactive sources, physical protection of sources in use, repatriation of disused sources and a better control of borders should enhance the good management and control of radioactive sources during their life cycle.

IAEA-CN-204/201

THE FRENCH EXPERIENCE REGARDING PEER REVIEWS TO IMPROVE THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

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Abstract

France has a 50 year history of control over radioactive sources. Convinced that peer reviews may be helpful to improve any regulatory system, France decided to experience a 'full scope' Integrated Regulatory Review Service mission in 2006 and its follow-up mission in 2009, including a review of the implementation of the Code of Conduct. The reviews, interviews and observations performed during these missions enabled the experts to have a thorough knowledge of the French system and to highlight its strengths and ways for improvements. Following these reviews, France decided to rely on its good practices, extend them as much as possible and to define, implement and address an action plan to improve its regulatory control over radioactive sources, while maintaining the prime responsibility on the operators. While good practices in the tracking of sources were maintained and slight evolutions were conducted in the safety regulations, licensing process, and inspection and enforcement actions, the major outcome of these reviews will obviously consist of the entrustment of the French Nuclear Safety Authority with the role of the regulatory authority for the security of radioactive sources and the implementation of dedicated provisions.

1. INTRODUCTION

France has long been aware of the need to maintain control over radioactive sources to protect workers, patients, the public and the environment from ionizing radiations. A regulatory control system, regulating the whole life cycle of sources, was therefore established more than 50 years ago, and it has been regularly updated since then.

In order to benefit from an external assessment of this system, the French Nuclear Safety Authority (ASN, Autorité de sûreté nucléaire) experienced in 2006 an Integrated Regulatory Review Service (IRRS) mission and, during the IRRS follow-up mission in 2009, the 'Code of Conduct part' of the review service. These reviews enabled — and will enable — France to improve its regulatory control over radioactive sources.

This paper gives a brief overview of the French regulatory framework and of the different stakeholders' responsibilities. Some highlights from the IRRS reports and the way some associated recommendations and suggestions were taken into account regarding the control over radioactive sources are then detailed.

2. THE FRENCH CONTROL SYSTEM AND THE DIFFERENT STAKEHOLDERS

2.1. The French legal framework

The legal provisions concerning radioactive sources are included in two legal codes: the Labour Code contains provisions related to occupational exposure; whereas the Public Health Code includes all the other provisions. These provisions cover the manufacturing, distribution, import, export, possession and use of radioactive sources.

This legal framework has been progressively improved. It should soon be updated to transpose the new European directive on basic safety standards and to cover the security of radioactive sources, following in this field the recommendation of the IRRS 2009 Report (cf. Section 4).

2.2. The different stakeholders and their responsibilities

2.2.1. The operators

The French control system over radioactive sources places the prime responsibility for radiation protection on the operators. These operators have to implement, at their own costs, every necessary preventive and protective measures against the risks their activities involve and to inform the public and the competent authorities as much and often as necessary.

It is also the operators' responsibility:

— To inform the competent authorities as fast as possible in case of an event, incident or accident that could cause harm to the public, the patients, the workers and the environment. In this purpose, complementing for medical exposure the International Nuclear Event Scale, the ASN and the French Society for Radiotherapy and Oncology jointly developed a dedicated event severity scale, which was highlighted as a good practice during the 2009 peer review.

— To analyse the reasons of this event and define what provisions need to be implemented to avoid its reappearance.

2.2.2. The authorities

Even if the prime responsibility remains on the operators, France tasked competent authorities to control practices involving radioactive sources:

— Prefects (i.e. the State's representatives in French districts) if the sources are held and/or used for non-medical purpose within installations subject to authorization procedures for environment protection (ICPE);
— Delegate for nuclear safety and radiological protection for activities and installations concerning defence (DSND) for the manufacturing, possession and use of radioactive sources inside military nuclear facilities;
— The ASN for all nuclear activities controlled by neither the Prefects nor the DSND. More precisely, this covers distribution, import and export in every installations and manufacturing, possession and use in installations controlled by neither the Prefects nor the DSND, including every job site.

Figure 1 outlines the organization of roles and responsibilities between the ASN and the operators.

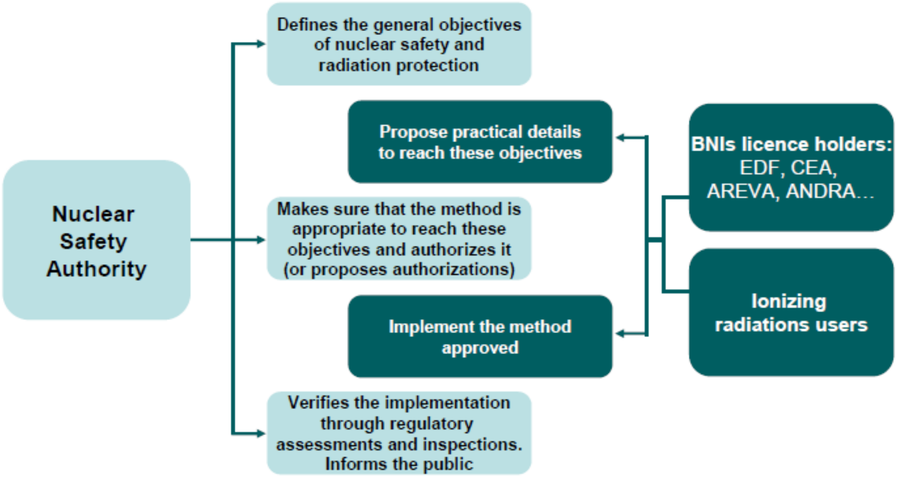

FIG. 1. Roles and responsibilities of the ASN and operators.

2.2.3. The Institute for Radiological Protection and Nuclear Safety

The Institute for Radiological Protection and Nuclear Safety (IRSN, Institut de radioprotection et de sûreté nucléaire) is the technical support organization for the different authorities, which may request its appraisal as necessary to assess the safety, the security and the radiological protection for activities involving radioactive sources.

The IRSN is also tasked to administer national databases such as the national inventory of radioactive sources, the national dose registry and the national database for environmental monitoring.

3. SOME HIGHLIGHTS FROM THE IRRS 2006 AND 2009 REPORTS

At the request of the French Government, the first 'full scope IRRS mission' was conducted at the ASN from 6 to 17 November 2006. In 2008, the ASN requested an IRRS follow-up mission, also extended to the 'Code of Conduct part' of the review service. This complementary review took place from 29 March to 3 April 2009.

These missions were thoroughly prepared by the ASN, using the self-assessment questionnaires provided by the IAEA, sending relevant documents to the experts and working as a project team. The missions both consisted of an intensive series of interviews and discussions with key personnel at the ASN and other organizations and the observation of a number of inspections across the whole scope of practices and activities, together with the review of documents and self-assessment reports supplied by the ASN in advance of the mission.

Action plans were systematically defined and addressed by the ASN to make sure that the reviewers' recommendations and suggestions were taken into account. Some highlights regarding the status of the ASN and the main highlights regarding the safety and security of radioactive sources are mentioned below.

3.1. Status of the ASN

The French regulatory framework for controlling sources has been significantly modified following the June 2006 law on transparency and security in the nuclear field. More specifically, this law established the ASN as an independent administrative authority and improved and clarified its status with regard to nuclear safety and radiation protection.

This law basically organizes the control of nuclear safety and radiation protection for civil use as follows:

(a) On the one hand, political decisions remain at the State level and are adopted by the Government upon advice of the ASN (creation or definitive shutdown and decommissioning of a basic nuclear installation — BNI — decree, implementing procedures for the Public Health Code or the Labour Code, among others).

(b) On the other hand, the ASN:
   - Contributes to drafting regulations, by giving the Government its opinion on draft decrees and ministerial orders, or by issuing technical regulatory decisions (which have to be approved by the concerned ministers);
   - Takes the individual decisions stipulated in the Public Health Code, which concern most of the activities involving ionizing radiation;
   - Is tasked to monitor compliance with general rules and special prescriptions regarding nuclear safety and radiation protection;
   - Participates in informing the public in its field of competence;
   - Takes part in the management of radiological emergency situations (emergency response plans and support to the Government in case of an emergency situation, among other things).

Following a recommendation of the IRRS 2006 Report, the Labour Code and the Public Health Code have been updated to take these statutory modifications into account. Moreover, as expected by the experts in 2006, the roles and responsibilities of the ASN and other State services (e.g. Ministry of Labour and Ministry of Defence) have been clarified (see also Section 3.4).

Finally, as independence may lead to isolation, the ASN puts strong emphasis to establish conventions and protocols with other stakeholders (see also Section 3.4), which was seen as a good practice.

3.2. The licensing process

A prior licence or registration is required to manufacture, possess, use, sell, import or export radioactive sources exceeding very low exemption levels or products or devices containing such sources. These exemption levels are defined by the European directive on basic safety standards.

The French legislation provides that a simple registration suffices to hold or use a radioactive sealed source in specific cases foreseen in regulatory decisions issued by the ASN. At this stage, this is only the case for ionizing smoke detectors held or used for another reason than only smoke detection (maintenance and teaching, among other things, except practices decreasing the radiation protection level which have to be first licensed). Any operator expecting to perform another nuclear activity with a radioactive source exceeding exemption levels has to be first licensed.

The operator is therefore to submit to the competent authority an application containing the relevant organizational and technical provisions it pledges to follow during the intended nuclear activity.

This licensing process was assessed by the reviewers and it was notably considered that, for the medical use of radioactive sources:

— The clarity of the requirements, forms and guidance for what needs to be submitted was good practice.
— For the purpose of simplification, however, the ASN should reconsider the necessity of requiring some information with poor added value, which was done.
— The internal procedures for reviewing and assessing the applications had to cover every field of use, which was done.
— The licensing process systematically resulted in either the granting of an authorization or its rejection, including the basis for the decision, which was seen as a good practice and is also applied to industrial applications.
— The development of templates for authorizations, which is also the case for the industrial use of sources now, was a good practice.
— The ASN would need to develop technological surveys, in collaboration with the IRSN, to assess the safety of new medical devices. As a matter of fact, the IRSN's appraisal is systematically requested in case of an application for such a device.
— The ASN should issue technical decisions that set radiation safety standards for nuclear medicine, brachytherapy and external beam radiotherapy installations, which was done.

The content of the licence should soon be enriched with requirements designed for security reasons.

3.3. The assessment of the applications

Depending on the nature of the required licence, the licensing process always includes an assessment by the competent authority that the nuclear activity is justified and a graded review of technical and organizational provisions regarding the training of workers involved in the use of radioactive sources, the user's source inventory, the design of the source, the radiation protection features of the device or the radiation protection conditions during storage and use of the source.

Basic provisions against source theft (such as the storage of unused sources in a safe) are also reviewed. Moreover, provisions dedicated to radiation protection, such as limited access by trained workers, storage of unused sources in a cabinet or safe or wall shielding, also contribute to source security.

Parts of this assessment were considered as good practices by the reviewers, notably the use of the principles of justification and optimization of the doses for medical exposure and the comprehensiveness of the assessment for industrial activities.

Some recommendations and suggestions were issued regarding, for example, the possibility for the ASN to lobby to increase the number of medical physicists or to encourage and assist professional societies so that publications are available on justification for all uses of radiation in medicine, among other things. All of them were taken into account, particularly for increasing the number of medical physicist in radiotherapy (the number has doubled since 2006).

The examples of ionizing smoke detectors, gamma blood irradiators and justification for medical exposure explained in Box 1 are interesting regarding the French use of the principle of justification.

3.4. Inspections and enforcement actions

Licensees are inspected by inspectors from the competent authority that granted their licence. Workers' protection against the dangers of ionizing radiation is also monitored by labour inspectors. The actions of the various authorities are coordinated by dedicated memoranda of understanding.

Two hundred and seventy-six of the 471 ASN employees are specifically trained and qualified inspectors, of which 147 perform radiation protection inspections. The reviewers considered in 2006 and 2009 that the French inspectors training programme was mature and well developed. However, they also recommended the ASN:

- To improve and facilitate the staff recruitment and the flexibility in order to obtain the necessary experienced staff on time and during the necessary period to carry out the regulatory activities;
- To significantly improve the exchange of experienced staff from the IRSN and other organizations.

BOX 1: THE USE OF THE PRINCIPLE OF JUSTIFICATION

Since 2002, the deliberate addition of radioactive substances in the manufacture of consumer goods and construction products is legally forbidden unless derogation is granted. Smoke detectors belong to this last category.

In France, smoke detectors with radioactive sources, called ionizing smoke detectors, were first used in the 1940s with radium or other sources. Since 1966, the use of ionizing smoke detectors has been forbidden in personal lodging but allowed in industrial or administrative buildings.

This justification has been reassessed in France in the light of technical developments of other types of detectors, such as thermal or optical smoke detectors. These 'non-ionizing' detectors now comply with the essential requirements of national standards and regulations for fire detection. Therefore, ionizing smoke detectors can no longer be installed in new buildings, and at the end of 2011, a transition period was defined to gradually remove the existing ionizing smoke detectors (7 million detectors assigned to 300 000 installations) (see Fig. 2).

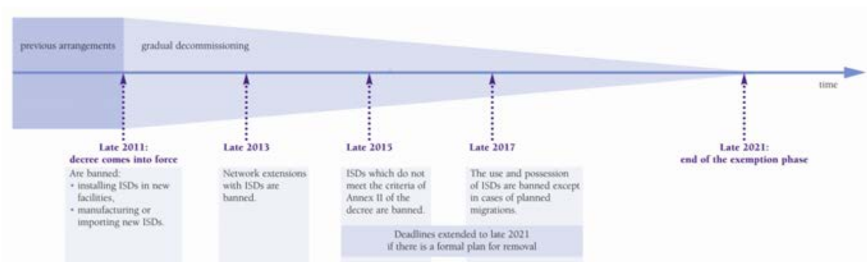

FIG. 2. Transition period for the removal of existing ionizing smoke detectors.

The process regarding gamma blood irradiators, even if also linked to justification, is a bit different since their substitution takes place on a voluntary basis.

In France, it is considered that, when correctly performed, blood irradiation is as efficient with X ray irradiators as with gamma irradiators. Therefore, as X ray irradiators are as efficient and less dangerous (no risk when not working) and as it is more stringent for them to deal with radioactive sources than with X ray devices, end users are progressively willingly substituting their gamma blood irradiators with X ray irradiators.

Finally, the ASN supported the update of a professional guide regarding the appropriate use of imaging exams, regularly alerts professionals on the increase in the doses received by patients for medical purpose and insists on the value of the use of magnetic resonance imaging versus radiological imaging when appropriate.

This recommendation, not fully in the hands of the ASN, will be taken into account to the extent possible. One hundred and two ASN employees are already experienced employees from the IRSN and other technically recognized organizations.

The frequency of the inspections is decided on a risk analysis basis. Following a suggestion of the 2006 report, the inspectors' feedback on specific practices (e.g. industrial radiography, research activities, radiotherapy, nuclear medicine and interventional radiology) is now collected and summarized at the national level. These summaries enable the ASN to decide inspection priorities and to adapt, when necessary, the frequency and content of the inspections. The frequencies of inspections of radiotherapy and interventional radiology units were increased, following the experience of several major events as well as the 2006 report's suggestions. Patient safety control is now considered as a high level of priority in the inspection programme.

ASN radiation protection inspectors performed 1050 inspections of sources' suppliers and of industrial, research and medical users of ionizing radiations in 2012 (53% in the medical field, 35% in the industrial and research field, and 9% in the veterinary field). More than 15% of them were unannounced.

During their inspections, the inspectors may rely on specific guidance, which was considered good practice by the experts. Those guidelines were complemented as requested by the reviewers (expansion to every field of use of sources and inclusion of organizational and human factors criteria). Thus, inspectors may make sure that the requirements of the laws, regulations and licences are fully respected. They have the legal capacity to set up proportionate enforcement actions to have those requirements fulfilled and the ASN, following a 2006 recommendation, developed a formal enforcement policy to help them in this mission. A follow-up letter is systematically sent to the licensee within three weeks after the inspection and published on-line (10 445 follow-up letters were available on the ASN web site at the end of 2012). This publication is considered by the reviewers as a powerful enforcement tool.

3.5. Tracking the sources

This part of the French system was assessed for the first time during the part of the IRRS 2009 follow-up mission dedicated to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [1].

3.5.1. The national register of radioactive sealed sources

The French national register of radioactive sealed sources was created in the 1950s, and it deals with every radioactive sealed sources exceeding the exemption level, which was considered during the IRRS mission as good practice. It enables the competent authorities to accurately track the users’ stocks. Some key numbers of this register are given in Box 2.

BOX 2: KEY NUMBERS

At the end of 2012, 45 428 sealed sources, 296 licensed suppliers and 5573 licensed users of sealed sources were registered in the national inventory. About 10 000 transfers of sealed sources are annually registered.

— The main radionuclides are ^{137}Cs (24%), ^{60}Co (12%), ^{90}Sr (9%), ^{57}Co (7%), ^{109}Cd (7%) and ^{241}Am (7%);
— The major practices relying on these sources are calibration (64%), analytical characterization (10%), industrial irradiation (4.5%), industrial gauges (9%), medical applications (4.5%) and industrial radiography (1.4%);
— About 10% of these sources are either high activity sealed sources according to Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources [2] or Categories 1–3 as defined by the IAEA categorization system.

The national register is an electronic database called SIGIS (Système d'information et de gestion de l'inventaire des sources) managed by the IRSN, whatever the competent authority for the licensee might be. As suggested by the 2009 report, the ASN, including its 11 regional divisions, now has full and real time access to the registered data.

Any transfer of a sealed source from a supplier to an end user or between end users is to be registered by the IRSN within SIGIS before taking place. In case of anomalies or doubts, the IRSN is to inform the competent authority and act according to the authority's final decision.

The regulatory framework foresees other means of control since:

— End users have to send annually to the IRSN a list of the sources they possess, which is cross-checked with the registered transfers.
— Suppliers have to send quarterly the inventory of the sources they acquired and transferred, which enables the IRSN to verify that all transfers have been registered.

3.5.2. The ten year lifetime of sealed sources and the financial guarantee

In the early 1990s, the French regulator noticed that:

— After ten years, many sources' suppliers had disappeared.
— The average duration of an end user's licence was ten years.

This turned out to become an issue when disused sources had to be safely managed.

On that basis, the French regulator decided that:

(a) The end user is to return to its supplier any unused sealed source and any source that was first registered at the latest ten years before. This general rule allows for exemptions and possible requests to extend the duration of use of sealed sources beyond ten years.
(b) Suppliers are to take back all the sealed sources they sold on the end user's request without condition.
(c) Sealed sources' suppliers are to subscribe to a financial security fund to ensure the safe and secure management of the sealed sources they distributed (e.g. in case of bankruptcy where the recovery process mentioned above would not be operating anymore).

These last two requirements were highlighted as good practices to promote by the IRRS mission.

4. A FUTURE MAJOR IMPROVEMENT IN THE SECURITY OF SOURCES

Radiation protection prudent management practices contribute to the protection of the sources against malicious acts. However, the dedicated security related principles of the IAEA Code of Conduct and the recommendations defined in the IAEA Nuclear Security Series publications have not been formally transposed into French legislation. Furthermore, no authority is officially tasked to control prevention measures against malicious acts targeting sources.

At the request of the French prime minister, the ASN submitted a plan to establish such a control. The ASN was also identified by the Government as the future competent authority in that regard.

The IRRS follow-up mission in 2009 provided very positive feedback on the implementation of the IAEA Code of Conduct and recommended that the "ASN should implement its proposal for the regulation of the security of radioactive sources expeditiously".

In this context, the Government submitted a bill to parliament to entrust the ASN with the role of the regulatory authority for the security of radioactive sources. This bill will improve the overall control of radioactive sources by strengthening existing control measures and including dedicated provisions for the prevention of malicious acts. In anticipation of the adoption of this bill, the Ministry of Ecology, Sustainable Development and Energy is currently preparing, in relation with the ASN, the IRSN and other relevant public stakeholders, draft regulations to include security aspects in the licensing process and strengthen security requirements for use, storage and transport of radioactive sources.

5. CONCLUSION

In France, nuclear safety and radiation protection have always been under the prime responsibility of the operators. However, France created in the 1950s a legal and regulatory control system over radioactive sources. This system was recently reviewed during two IRRS missions and considered as covering the safety requirements of the Code of Conduct. These peer reviews highlighted some possible improvements, especially the entrustment of the ASN with the role of the regulatory authority for the security of radioactive sources and the implementation of dedicated provisions that will enable our system to be comprehensive regarding the Code of Conduct's standards.

REFERENCES

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PANEL 2

EDUCATION AND TRAINING

Chairperson: **F. Morris** (United States of America)

Rapporteur: **W. Rhodes** (United States of America)

AN OVERVIEW OF A PUBLIC HEALTH POSTGRADUATE COURSE FOR THE EDUCATION AND TRAINING OF RADIATION PROTECTION OFFICERS

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Abstract

The nationwide modernization of Panama, initiated about eight years ago, contributed immensely to the creation of a postgraduate programme in radiation protection to prepare qualified individuals to carry out radiation protection responsibilities. The modernization process involved diverse projects, and some comprised the use of radioactive materials, primarily in the construction of numerous infrastructures. To identify a few: the expansion of the Panama Canal, the Metro Rail System, and the implementation of facilities with industrial and medical irradiators. The former operating a ^{60}Co source of 7.22×10^8 MBq, used for the eradication and prevention of screwworm in cattle; and the latter a ^{137}Cs source of 5.39×10^7 MBq, for the irradiation of blood. Similarly, the dissemination of numerous density gauges that used ^{137}Cs source and moisture density gauges with ^{241}Am/Be, mainly used in the building of highways and roads throughout the territory.

The proliferation of radioactive materials in the country prompted concerns of public health issues of foreseeable potential effects from these sources; similarly, it triggered an immediate problem for the Regulatory Authority regarding non-regulatory control of many of the sources. With respect to the matters at hand, the Regulatory Authority prioritized its concerns on strengthening its national regulatory control programme by establishing a postgraduate course to educate and train individuals for future assignments as radiation protection officers; to guarantee an appropriate framework of radiation safety and security of radioactive sources.

1. INTRODUCTION

In early 2010, the Regulatory Authority established a Statement of Understanding with the United States Nuclear Regulatory Commission (NRC). Under the provision of this document, the NRC sponsored the first postgraduate course in 2010 and a second in 2012. The duration of the programme was protracted over a period of ten months and designed encompassing a public health perspective. The IAEA subsidized both courses and sponsored instructors from relevant regulatory authorities in the Latin American Region, specifically from Brazil, Chile and Cuba. It is essential to address that from the onset of the programme, two graduations have taken place, one in 2011 of 10 graduates, and another in 2012 of 14. All graduates received immediate employment at diverse radiological facilities on completion of the programme.

2. PURPOSE

The primary purpose of the postgraduate education and training programme is to prepare individuals to become qualified radiation protection officers.

3. OBJECTIVES

The objectives are:

— To prepare qualified individuals with the academic, technical and operational aspects of radiation safety and the security of radioactive materials to enable them to assess situations to prevent individuals and the environment from the harmful effects caused by ionizing radiation;
— To develop the necessary skills and abilities that will enable the participants to rationalize the uses of ionizing radiation sources to benefit the health and societies well-being;
— To provide administrative skills to the participants that will enable them to develop, manage and implement effective programmes regarding radiation protection and the security of radioactive materials;
— To prepare the participants to qualify for their licences or work permit, once graduated, in compliance with the requirements set by the Technical Counsel of Health, of the Ministry of Health.

4. SCOPE

The aim of the course is to provide the participants with a sound academic and practical training in radiation protection and the security of radioactive materials.

5. PROGRAMME ORGANIZATION

The postgraduate programme was organized by the Department of Public Health, of the Ministry of Health, with technical support from the Section of Radiation Health, of the Ministry of Health. The Faculty of Medicine of the University of Panama collaborated with professors from the School of Public Health. The NRC sponsored the entire programme, including financial funding of instructors salaries, the purchase of radiation detection instruments for laboratories exercises and the procurement of relevant text books and handbook manuals. The NRC also provided RASOD, a database program, to register ionizing radiation sources and information regarding authorization process. Moreover, the NRC subsidized a national inventory concerning radiation sources. The data collected revealed radiation sources with activities sorted in Categories 1–5, in concordance with the categorization system established by the IAEA — where Category 1 denotes the category of maximum risk. The programme's progress was periodically assessed by prominent professionals in the field of radiation protection, previously assigned as advisors, from Chile, Cuba and the United States of America.

6. NATURE OF THE PROGRAMME

The programme's format provides both theoretical and practical training in the development of radiation protection philosophy, principles, standards and their implications. Similarly, emphasis is oriented to public health problems, associated with ionization radiation and the Code of Conduct on the Safety and Security of Radioactive Sources. The programme's platform comprises four modules: three of lectures and one of practical training. The dynamics of the programme entails lectures, essays, group discussions, laboratory exercises, field visits, examinations and special guest speaker presentations. The programme consists of 12 lectures per week, in the evenings of Monday, Wednesday and Friday, 17:30–21:30. A total of 350 hours are allocated to lectures and laboratories exercises and 360 hours to practical training. The programme is protracted over a period of 10 months, comprising 710 hours. Concerning the cost of the postgraduate programme for 2011 and 2012: the former covered instructor's fees, travelling expenses, audiovisual equipment, as well as laboratory instruments and equipment, for a total cost of US $45 000. The expenditure for the latter year only included instructors' fees, their corresponding travelling per diem and miscellaneous costs for a total of US $15 000. The programme was of no cost to the participants.

7. REQUIREMENTS FOR ADMISSION AND GRADUATION

Candidates for the academic and training programme in radiation protection are selected from applicants holding a Bachelor degree in physics, mathematics, chemistry, biology, computer science, engineering or medicine. In addition, because of the physical science and mathematics nature of the programme, all candidates must present an admission test and score greater than 71/100.

To approve the programme, the participant:

(1) Must have 90% attendance in each course.
(2) Must approve each course with a minimum score of 75/100.
(3) Is given the opportunity to retake the test when the average score is between 65/100 and 74/100 in any of the courses. If the score is less than 75/100, he is automatically dismissed from the programme.
(4) Will not be able to pass onto another module if condition 3 is not fulfilled.
(5) Must achieve a 90% attendance of the practical training.

The final score or grade is as follows:

— A = 100–91;
— B = 90–81;
— C = 80–75;
— <75 dismissed from the programme.

8. CERTIFICATION AND PROFILE OF THE GRADUATE

The participant that passes the programme is awarded a diploma with the title Radiation Protection Officer. The diploma is recognized and accepted by the Technical Council of Health, of the Ministry of Health, which extends professional licences to all processionals that work in the field of medicine and public health. Moreover, the Faculty of Medicine of the University of Panama recognizes the programme. The Panamanian Association of Radiation Protection also approves the programme.

Upon graduation, the radiation protection officer is a professional, fully qualified to assume duties in installations that use ionizing radiation: for example, in hospitals and public health centres, academic institutions (universities), and a variety of industries and research centres.

9. FACULTY

To be part of the faculty, the instructor must hold a doctorate or Master degree in radiological health, radiation protection or a related field, and, in addition, two or more years of experience in one of those fields.

The faculty may consist of national and foreign professionals with a wide range of experience in the field of radiological health, radiation protection, nuclear safety and related matters, and have developed their activities and experiences in the areas of medicine, industry, education, research, management, regulatory control and corresponding related specialties.

10. COURSE OUTLINE

Details of the courses outline per module are in Table 1.

11. COURSE DESCRIPTION

Details of the courses description per module are in Table 2.

12. SUMMARY

The overriding purpose of the postgraduate programme in radiation protection is to provide properly trained individuals to function as operators, regulators, instructors, administrators and advisors in the recognition, prevention and management of health issues, concomitant with practices that use ionizing radiation. To accomplish such goal, the Department of Public Health of the Ministry of Health, developed a postgraduate programme with its implementation in 2010. The programme is designed to promote a culture regarding the code of conduct on radiation safety and security of radioactive materials, superseding public health issues. The programme comprises four modules, three of lectures and one of practical training, protracted over a period of ten months. Upon completion, the participant is awarded a diploma with the title radiation protection officer. All 24 graduates of 2011 and 2012 have received immediate employment in radiological facilities — enabling the facilities to comply with the requirements and regulations established by the regulatory authority. The Faculty of Medicine of the University of Panama collaborated with instructors from the School of Public Health. It is important to state that the NRC financially sponsored the entire programme and the IAEA contributed several guest speakers.

TABLE 1. STRUCTURE OF THE COURSE OUTLINE

Module	Subject	Code	Lectures (hours)	Laboratory (hours)	Training (hours)	Total (hours)
I	Radiation Physics	RPOI–100	32	10	None	42
	Fundamentals of Epidemiology	RPOI–200	14	4	None	18
	Biostatistics	RPOI–300	20	8	None	28
	Radiation Protection	RPOI–400	22	8	None	30
	Biological Effects of Ionizing Radiation	RPOI–500	18	None	None	18
	Total		106	None	None	136
II	Radiation Detection and Measurements	RPOII–100	30	8	None	38
	Evaluation of External and Internal Exposures	RPOII–200	18	None	None	18
	Regulatory Control	RPOII–300	18	None	None	18
	Principles of Administration	RPOII–400	14	None	None	14
	Safety of Radioactive Waste Management	RPOII–500	20	6	None	26
	Total		100	14	None	114

TABLE 1. STRUCTURE OF THE COURSE OUTLINE (cont.)

Module	Subject	Code	Lectures (hours)	Laboratory (hours)	Training (hours)	Total (hours)
III	Quality System: Application to Medicine and Industry	RPOIII–100	40	14	None	54
	Safe Transport of Radioactive Material	RPOIII–200	14	4	None	18
	Environmental Radiation: Survey, Monitoring and Radiological Emergency	RPOIII–300	20	8	None	28
	Total		74	26	None	100
IV	Practical Training	RPOIV–100	None	None	360	360
Total			280	70	360	710

TABLE 2. COURSE DESCRIPTION

Module	Subject	Code	Description
I	Radiation Physics	RPOI–100	Radiation: electromagnetic radiation and ionizing vs non-ionizing radiation; structure of the atom: radiation from electron transitions, characteristics X rays, Auger electrons and fluorescent yield; atomic nucleus; composition, nuclear forces and energy levels, classification of nuclides, nuclear stability; radiation sources: radioactivity, transformation mechanism, transformation kinetics, activity, naturally occurring radiation, serial transformation; interaction of radiation with matter, particle interactions, excitations, ionization and radioactive losses, specific ionization, charge particle tracks, linear energy transfer; Compton scattering, photoelectric effect, pair production; attenuation of X rays and gamma rays, linear attenuation coefficient, mass attenuation coefficient, half value layers and neutrons; absorption of energy from X rays and gamma rays: fluence, flux and energy fluence; kerma: mass energy transfer coefficient; absorbed dose, exposure; criticality: criticality hazard, assessment of hazard and optimization.
	Fundamentals of Epidemiology	RPOI–200	Definition of epidemiology, epidemiological studies on mortality, morbidity, cohort studies: retrospective and prospective, epidemiological research, comparison of models of absolute and relative risk, cost–benefit analysis and the assessment of the risk of exposed populations.
	Biostatistics	RPOI–300	Definition; concepts, measures of continuous and discrete data; rates and standardization; life table; probability theory and distributions; population parameters and their sample estimates; descriptive statistics for central tendency and dispersion; measures for categorical data; normal distribution; analysis of variance, chi-square statistics: contingency tables, multiple contingency tables; linear correlation and regression; logistic regression; theory of sampling and statistical inference, including hypothesis testing, p-values and confidence intervals.

TABLE 2. COURSE DESCRIPTION (cont.)

Module	Subject	Code	Description
	Radiation Protection	RPOI–400	Definition, history, philosophy, and principles of radiation protection; role of the radiation protection officers; elements of a radiation protection programme; national and international organizations that sets standards; basic radiation quantities and units, methods of radiation protection; occupational, medical and public exposures; external radiation safety: basic principles, point source, line source, plane source, and volume source; personnel monitoring, classifications of areas; radiation monitoring of the work place; shielding principles and calculations; types of contamination, assessment and decontamination; management requirements, philosophy of the code of conduct on the radiation safety and security of radioactive sources; physical security, technological security, illicit trafficking of radioactive material, control systems and supervision; overview of relevant radiation accidents and lesson learned.
	Biological Effects of Ionizing Radiation	RPOI–500	Structure and cell division, direct and indirect action of the radiation; chromosomes: structure and biological function; dose relationship, radiosensitivity; effect of oxygen, protective radiosensitizers and radio players, whole and partial; body irradiation effects of radiation and their modifications; damage to the nervous system and organs; classification of the biological effects: stochastic and deterministic; induce carcinogenesis: radio epidemiological studies, risk projection models.

TABLE 2. COURSE DESCRIPTION (cont.)

Module	Subject	Code	Description
II	Radiation Detection and Measurements	RPOII–100	Statistical nature of radiation and error prediction; general properties of radiation detectors: ionization chambers, proportional counters, Geiger–Müller counters; scintillation detector principles: photomultiplier tubes and photodiodes; radiation spectroscopy with scintillators, semiconductor diode detectors, Germanium gamma rays detectors and other solid state detectors; slow neutron detection methods, fast neutron detection and spectrometry; processing and shape of the pulse methods: linear and logical functions; multichannel pulse analysis; background and detector shielding.
	Evaluation of External and Internal Exposures	RPOII–200	Dosimetrics and operational quantities, monitoring programme for the assessment of individual doses: programmes design for monitoring, personal dosimetry, effective on several conditions of external exposure, dose assessment personal dosimeters built-in type: TLD, films, ionization chambers, etc.; the use of electronic personal dosimeters, requirements of performance for the personal dosimeters, whole body, extremity, and skin dosimetry; evaluation of routine, special and accidental; dosimetry, analysis of uncertainties: type A, type B; programme for monitoring the workplace, routine tasks and monitoring, interpretation of measurements, calibration, quality assurance, input modes; programmes for monitoring, ICRP biokinetic; calculation of the committed effective dose.

TABLE 2. COURSE DESCRIPTION (cont.)

Module	Subject	Code	Description
	Regulatory Control	RPOII–300	Legal framework, the regulatory authority: mandate of regulatory authorities, organizations, adequate resources; training, staff requirements; advisory committees; regulatory system: regulations, rules, and practical guides; responsibilities and functions; system notification, registration, licence and control of radiation sources, including criteria for the storage of radioactive waste and disposal; exemption, dispensation; national inventory sources, orphan sources, import, export, transport, security assessment: compliance with the requirements of safety, radiological inspection, coercion, requirement for training, radiological emergency preparedness: investigation of accident and emergency management; regulatory assessment: methodology to assess the effectiveness performance indicators, performance criteria; peer review and safety culture of staff at all levels.
	Principles of Administration	RPOII–400	Introduction, concept, evolution of management, administration theory, elements of administration, planning, organization, supervision, evaluations, and administration technology.
	Safety of Radioactive Waste Management	RPOII–500	Introduction, concept, protection of human health and the environment from radioactive waste, strategies and policies for the management of radioactive waste, origin and type of radioactive waste, waste classification; principles of radioactive waste management, waste minimization; management of waste from decommissioning, overview of the regulatory environment for installations and activities, safe storage of radioactive waste, overview of closure elements related to security, overview of the elements related to security in the rehabilitation of existing scenarios, management of naturally occurring radioactive material waste and cleanup of contaminated areas.

TABLE 2. COURSE DESCRIPTION (cont.)

Module	Subject	Code	Description
III	Quality System: Application to Medicine and Industry	RPOIII–100	Definition, concepts, philosophy; international organizations, ISO 9000:2000; quality management and quality system elements; safety standards and the security of radioactive sources; quality system: quality assurance, quality control, protocols, procedures, acceptance tests, performance tests, level of accuracy, reliability, conformation; commissioning; calibration of equipment and instruments, certification, the uses of phantoms, documentation, records keeping and control; guidelines and recommendations for the setting up of national programmes; physical and technical aspects of quality control in: diagnostic radiology, nuclear medicine, radiotherapy and industrial applications.
	Safe Transport of Radioactive Material	RPOIII–200	Definitions; national regulations and international recommendations; radiation protection and security of radioactive material sources; activity limits and classifications; requirements and control for transport, requirements for radioactive materials and for packaging and packages, test procedures, approval and administrative requirements and emergency response.
	Environmental Radiation: Survey, Monitoring and Radiological Emergency	RPOIII–300	Systems of environmental management, responsibilities, legal aspects, means that lead to environmental impact; technical aspects; pollution, environmental assessment; environmental monitoring, principles for intervention, emergency response, emergency preparedness; implementations of emergency response plans, assessment, radiological emergency, emergency monitoring overview, field radiation and contamination monitoring; methods of decontamination, radiation protection of monitoring teams; basic data evaluation; medical management; communication and international cooperation.

TABLE 2. COURSE DESCRIPTION (cont.)

Module	Subject	Code	Description
IV	Practical Training	RPOIV–100	The practical training is carried out over a period of 360 hours; participants function as radiation protection trainee, assigned to practices that uses ionizing radiation; instructor close supervision evaluate the participants knowledge, skills and progress.

The total cost for the postgraduate programme was US $60 000. The expenditure was US $45 000 for 2010 and US $15 000 for 2012.

13. CONCLUSION

Outstandingly, the purpose and milestones of the postgraduate programme course were accomplished through the graduation of 24 professionals as radiation protection officers. Hence, the course programme’s format contributed effectively in the shaping of professionals to assess all types of activities involving ionizing radiation. Therefore, all graduates are prepared to set standards, recommendations and provide measures in order to prevent individuals and the environment from the harmful effects of such radiation.

The collaboration and guidance from the National Regulatory Authority, the NRC and the IAEA were fundamental, thus paving the way in the achievement of the programme’s goals.

Notably, the strategy applied throughout the whole programme, concerning the fostering of the code of conduct on radiation safety and the security of radioactive materials rendered multiple benefits postgraduation. For example, a number of radiation facilities, through their legal representative, have applied to the regulatory authority to initiate the process of authorization in order to use ionizing radiation. Such initiative prevents and minimizes the likelihood of orphan sources, theft, malicious acts and unauthorized transfer of radioactive sources throughout the State.

In addition, numerous radiation facilities have accepted the postgraduate programme, as well as the public health community. Several institutions of higher education (universities) have outpoured their interest in implementing a similar programme at the Master level. Moreover, States in the Latin American region have shown their interest in implementing a similar programme, particularly those that have a national regulatory authority within their Ministry of Health.

Finally, but of equal importance, the Government, through the Ministry of Health, exhibited support and endorsed educational and training programmes to prepare radiation protection officers, by enacting Resolution No. 2 of 8 February 2013 recognizing the specialty of radiation protection officers throughout the territory.

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SECURITY OF RADIOACTIVE SOURCES DURING TRANSPORTATION IN NIGERIA

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Abstract

The national experience since the inception of the Nigerian Nuclear Regulatory Authority (NNRA) has shown that radiological incidents and accidents, especially the loss of control of radioactive sources, have occurred during transportation. This thus forms the weakest link in the chain of import–transport–use–transport–export of radioactive sources. Radioactive sources are put to many beneficial applications in many sectors of the economy, including the petroleum industry, health care delivery, manufacturing industry, mining, education, research, and agriculture and water resources. It is pertinent to know that all radioactive sources used in Nigeria are imported and are subject to land and water transportation from their entry into the country, movements around various work sites and final export out of the country.

It is noteworthy that despite the immense activity going on in the handling, clearing and transportation of radioactive sources practice, only few transporters and licensed clearing agents were authorized to deal with radioactive sources. It was in that regard the NNRA observed that all cases of loss of control of radioactive sources during transportation have involved unlicensed handlers. This therefore underscored the urgent need to strengthen the Regulatory Control Programme and the requirements for the authorization of handling, clearing and transportation practices to ensure the safety and security of radioactive sources during transportation and in transit.

1. INTRODUCTION

The Nigerian Nuclear Regulatory Authority (NNRA) has, as part of its statutory responsibilities under the Nuclear Safety and Radiation Protection Act 19 of 1995 (the Act), responsibilities for nuclear safety and radiological protection regulation and the categorization and licensing of activities involving the handling and transportation of radioactive sources [1].

Radioactive sources are put to many beneficial applications in many sectors of the Nigerian economy. These sectors are the petroleum industry, health care delivery, manufacturing industry, mining, education, research, and agriculture and water resources. It is pertinent to know that all radioactive sources used in Nigeria are imported and are subject to land and water transportation from their entry into the country, movements around various work sites and final export out of the country. Our national experience since the inception of the NNRA has shown that radiological incidents and accidents, especially loss of control of radioactive sources, have occurred during transportation. This thus forms the weakest link in the chain of import–transport–use–transport–export of radioactive sources.

In this regard, the transport of the sources is to be in conformity with international standards of safety and security, especially those of the IAEA. Consequently, the Nigerian Transportation of Radioactive Sources Regulations, 2006, with its basis being IAEA Safety Standards Series No. TS-R-1, Regulations for the Safe Transport of Radioactive Material [2] and Nigerian Safety and Security of Radioactive Sources Regulations were gazetted to bring this practice in line with international norms. It is noteworthy that despite the immense activity going on in the handling, clearing and transportation of radioactive sources practice, only few transporters and licensed clearing agents were authorized to deal with radioactive sources. It is in this regard that the NNRA observed further that all cases of loss of control of radioactive sources during transportation have involved unlicensed handlers. This therefore underscored the urgent need to strengthen the Regulatory Control Programme and the requirements for the authorization of handling, clearing and transportation practices.

2. LEGISLATIVE AND REGULATORY INFRASTRUCTURE

The Act provides for the establishment of the NNRA, which was established in May 2001 [3].

2.1. Responsibilities

The NNRA has as part of its statutory responsibilities under section 4 of the Act, which includes, but is not limited to:

(a) Regulating the possession and application of radioactive substances and devices emitting ionizing radiation;

(b) Ensuring the protection of life, health, property and the environment from the harmful effects of ionizing radiation while allowing beneficial practices involving exposure to ionizing radiation;
(c) Regulating the safe promotion of nuclear research and development and application of nuclear energy for peaceful purposes;
(d) Advising the Federal Government on nuclear security, safety and radiation protection matters [1].

2.2. Power

To discharge these responsibilities, the NNRA is, among other things, empowered by section 6 of the Act:

(a) To categorize and license activities involving exposure to ionizing radiation, in particular, the possession, production, processing, manufacture, purchase, sale, import, export, handling, use, transformation, transfer, trading, assignment, transport, storage and disposal of any radioactive material, nuclear material, radioactive waste, prescribed substances and any apparatus emitting ionizing radiation;
(b) To establish appropriate register for each category of sources or practices involving ionizing radiation;
(c) To issue codes of practice which are to be binding on all users of radioactive and prescribed substances and of source of ionizing radiation;
(d) To review and approve safety standards and documentation;
(e) To provide training, information and guidance on nuclear safety and radiation protection;
(f) To protect the health of all users, handlers and the public from the harmful effects of ionizing radiation [1].

3. REGULATORY CONTROL PROGRAMME

Since its inception, the NNRA has emplaced a best regulatory framework within the context of the Act to effectively fulfil its primary regulatory functions: namely, radiation protection, safety and security of radioactive sources, safeguard of nuclear materials and the physical protection of nuclear facilities. This has been achieved through a system of registration, licensing and inspection of practices involving ionizing radiation and the enforcement of compliance with the Act. It has also taken necessary measures to have in place the basic administrative and technical capability to support its activities. In pursuance of the fulfilment of its regulatory functions as contained in the Act, NNRA activities are guided by the five pillars of the Regulatory Control Program:

(1) Regulations and guidance;
(2) Authorization;
(3) Oversight functions;
(4) Emergency planning and response;
(5) Ancillary functions.

3.1. Regulations and guidance

The provision of section 47 of the Act empowers the NNRA to make regulations with the approval of the president. In this regard, the Nigeria Basic Ionizing Radiation Regulations were gazetted in December 2003. This was the first set of regulations in the history of the country controlling the use of ionizing radiation. The NNRA further promulgated nine:

(1) Nigerian Safety and Security of Radioactive Sources Regulations, 2006;
(2) Nigerian Radiation Safety in Diagnostic and Interventional Radiology Regulations, 2006;
(3) Nigerian Radiation Safety in Nuclear Medicine Regulations, 2006;
(4) Nigerian Radiation Safety in Radiotherapy Regulations, 2006;
(5) Nigerian Radiation Safety in Industrial Radiography Regulations, 2006;
(6) Nigerian Transportation of Radioactive Sources Regulations, 2006;
(7) Nigerian Radioactive Waste Management Regulations, 2006;
(8) Nigeria Naturally Occurring Radioactive Material Regulations, 2008;
(9) Nigeria Radiological Safety Regulations for Nuclear Well-Logging, 2008.

The Nigerian transportation of radioactive sources regulations contain provisions such that:

(a) An application for licence to transport radioactive material or nuclear material is to contain the date, time and location of any scheduled stop or trans-shipment in Nigeria (Regulation 5.a).
(b) The Authority is to review, approve, reject applications, and issue, amend, modify, suspend, cancel licences or authorizations in respect of transportation of radioactive material (Regulation 10).
(c) Regulation 14 requires that a consignor, carrier and consignee of radioactive materials within Nigeria have valid licence from the Authority and notify the Authority well in advance and prior to the delivery, transport and receipt of any such materials.

(d) It is required that, for shipment by road, the vehicle must be dedicated for the purpose of transportation of radioactive materials only and all relevant particulars of the vehicle must be submitted to the Authority (Regulation 14.1).
(e) The regulations also make provisions for packaging, markings, labelling, placarding and segregation.

The Nigerian safety and security of radioactive sources regulations specify that the licensee is to have the responsibility for the safe management and security of radioactive sources involved for which the licensee is authorized and is to emplace and implement programmes and procedures for security of radioactive sources within his practice and for the administration of radiation safety (Regulation 2.a).

3.2. Authorization

By the powers conferred on it by sections 6, 18 and 19 of the Act, the NNRA authorized among other practices in industry (industrial radiography and nuclear well logging), medical applications and transportation of radioactive material. Non-compliance with any section of the Act and the above mentioned regulations is a contravention of the law. The NNRA has issued authorizations for transportation of radioactive sources since 2006, which is evident from Table 1 and Fig. 1, where there was a case of no existing authorized transporter of radioactive sources in 2001 and just one authorized transporter in 2007 to 11 as of June 2013. This development has reduced the cases of loss of control of radioactive sources as a result of increased number of licensed operators.

TABLE 1. AUTHORIZATION ISSUED IN THE LAND AND MARINE TRANSPORT

Type of transport	Year						
	2007	2008	2009	2010	2011	2012	2013[a]
Land	1	2	5	5	9	9	5
Marine	—	—	7	8	9	13	11

Source: Department of Authorization and Enforcement, NNRA.
[a] Licensed operator as of June 2013.

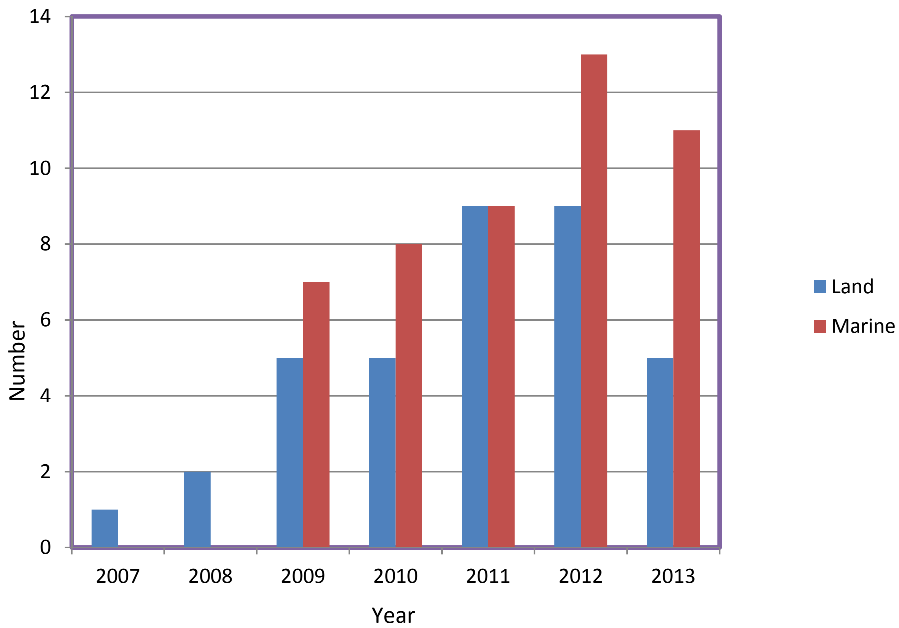

FIG. 1. Authorization granted in land and marine transportation.

The transportation of radioactive sources regulations specified that the Authority is to make available copies of authorizations for the transportation of radioactive materials to the law enforcement agents and other relevant government agencies for their information and other necessary actions (Regulation 11). This measure would enable the Nigeria Customs Service to identify unauthorized operators.

3.3. Terms and conditions of the licence

The licence for transportation of radioactive sources (in this case for marine transportation) is accompanied with specific terms and conditions, among others, such as:

(a) The Licensee is authorized to handle and provide marine transportation of radioactive sources within Nigeria using the vessel(s) specified (the particulars of the vessel is stated in the licence). Figure 2 shows a typical vessel used for transporting radioactive sources.
(b) Physical security of radioactive sources at all stages of transportation is the responsibility of the licensee until they are delivered to their licensed owners.

FIG. 2. Typical vessel used for transporting radioactive sources.

(c) The licensee is to ensure that sealed sources are locked in shielded positions, the key removed and all required plugs or caps installed and where possible, locked in place.

(d) The licensee is to ensure that appropriate transport labels are applied to the outer surfaces of packages based on radiation levels.

(e) The licensee is to ensure that all shipments carry appropriate documents including valid leak test certificates, consignor statements and emergency response plans.

(f) The licensee is to ensure that licensed vessels are placarded on both sides with radiation or trefoil signs.

(g) The licensee is to ensure that every member of its transportation crew, including the captains of the vessels, have basic training in radiation protection, handling and safe transportation of radioactive materials and security of radioactive sources.

(h) There is to be no loading or unloading operations during transportation of radioactive sources.

(i) The licensee is to submit to the Authority quarterly log records of movement of radioactive sources and display conspicuously a copy of the licence on dedicated vessels.

3.4. Emergency planning and response

The NNRA is empowered to establish in cooperation with other competent national authorities, plans and procedures which are to be periodically tested and assessed for coping with any radiation emergency and abnormal occurrence involving nuclear materials and radiation sources.

The National Radiological Emergency Preparedness Programme was drafted in 2006 and is being integrated into the National Disaster Response Plan of the National Emergency Management Agency.

The Nigerian safety and security of radioactive sources states that the transportation of radioactive sources to temporary job sites, including the packaging, marking, labelling and placing of such sources in vehicles, placarding of vehicles, securing the sources during transportation and possessing proper shipping papers and emergency response information (Regulation 14.2.j). The operator is to submit its emergency plan to the Authority for approval.

3.5. Ancillary functions

The Act empowered the NNRA to provide training, information and guidance on nuclear safety and radiation protection.

3.5.1. Seminars and workshops

Since 2002, the NNRA has instituted annual training workshops and seminars on radiation safety in the petroleum industry and for the medical sector. These events may be independently organized by the NNRA or in cooperation with other agencies or the IAEA. These events are for radiation employers in all endeavours involving ionizing radiation. They are generally to ensure that radiation employers are aware of their duties and responsibilities under the Act and also to promote the security and safety of radioactive sources. Furthermore, nuclear safety and radiation protection of personnel, patients and the public has been a common feature of such events. A list of the major workshops organized in the area of security during transportation includes:

(a) National workshop on security of radiation sources in land and marine transport organized by the NNRA in cooperation with the Federal Ministry of Transport and the IAEA at the Sheraton Hotels and Towers from 3 to 7 November 2008.
(b) One day technical meeting with cargo airlines operating in Nigeria organized by the NNRA at the Sheraton Hotels and Towers on 16 April 2009.
(c) The national workshop in (a) was also organized in 2010.

3.6. Oversight functions

Various forms of inspection — namely, pre-authorization inspections, pre-shipment inspections, audit inspections, investigative inspections and compliance inspections — are carried out by the NNRA as part of the authorization and enforcement processes.

The applicant's facility is scheduled for pre-authorization inspection upon satisfactory document and assessment with the view to verifying claims made on the application form with regard to road worthiness of the vehicle in case of land transport and the ship meeting International Maritime Organization and Nigerian Maritime Administration and Safety Agency requirements, staff competencies, safety and radiation protection programmes. The submission and review of report is to determine issuance or denial of authorization.

3.6.1. Inspection

Once documentation is received and the assessment is satisfactory, a pre-authorization inspection is conducted. The objective is to verify claims made on the application form with regard to temporary storage area where radioactive source consignment can be kept when there delay to proceed with the transportation, staff competencies, safety and security plan. An inspection report is submitted and reviewed, which will lead to the eventual issuance or denial of authorization with specific terms and conditions.

3.6.2. Enforcement

The greatest challenge faced by the NNRA in the first five years of its existence was the unauthorized movement of radioactive sources on land and water and the lack of knowledge of what they were transporting. The period under review recorded the under listed incidents.

(a) Misdeclaration and illegal exportation of radioactive sources

In December 2004, an industrial radiography company was duly authorized to export two spent radioactive sources (^{192}Ir and ^{75}Se) from a designated airport but chose to use a different airport without authorization. In the process, the licensee transferred the already inspected and properly labelled consignment to an unauthorized freight forwarder, which in turn illegally transported the radioactive package by road over a distance of about 500 km to a different airport. The freight forwarder or his agent shipped the consignment of radioactive material without declaring it to be such, a gross violation of the Act. Its external surface was not marked or labelled as dangerous goods and no shipper's declaration of dangerous goods accompanied the consignment, which upon inspection at the destination in Europe was discovered to be a correctly marked and labelled wooden crate, which had been overwrapped with a fibreboard box that was unmarked. The consignment escaped the attention of the Nigerian customs because of the wrong labelling and because there was no portal radiation monitor at this airport. The companies were both convicted.

(b) Loss of control of radioactive sources during transit

In October 2006, a nuclear well logging company reported the loss of Category 5 (^{137}Cs) and Category 4 (Am-Be) sources while on the premises of a multinational oil company. Intensive search operations for the sources have been carried out since then and are still going on by the NNRA, the police, the State Security Service and the armed forces. The sources are yet to be found. The Interministerial Nuclear Security Committee established several contraventions of the Act by both companies. In view of the development, both companies were prosecuted.

(c) Missing radioactive sources

An indigenous industrial radiography company reported a ^{75}Se source in a Delta 880 Projector contained in a Ford Ranger pick-up, which went missing following a road accident when it was taken out for work on 24 March 2013 to the facility of one of its client. The transport vehicle had a riveted container with padlock at the back of the vehicle, which was not locked because the radiographer could not found the key to the padlock and was a hurry to reach home due to a distressed call to attend to his sick baby. The RSO initiated a search in conjunction with his radiographers but could not find the source. The RSO further initiated a public awareness campaign to the community where the incident occurred and inform them of the danger associated with keeping radioactive source. The public awareness paid off which led to the discovery of the source on 30 March 2013. The incident was investigated by the NNRA and recommendations were made to be implemented by the operator and further actions are being considered by the NNRA.

4. STRATEGY TO COMBAT UNAUTHORIZED MOVEMENT OF RADIOACTIVE SOURCES

The NNRA is also empowered under section 6.j to do everything necessary to ensure that all concerned persons and bodies comply with laid down regulations under the Act. To achieve compliance with requirements and extant laws, the NNRA organized a stakeholder workshop in 2008 and meetings to sensitize the stakeholders in the land and marine transport of radioactive sources in accordance with the above mentioned regulations. The NNRA had series of meetings with the major oil and servicing companies, where they were urged to mandate their client, the transporters of radioactive sources especially the marine transporters for dialogue. The NNRA enforces compliance by ensuring that:

(a) No person or organization is to import, transport, use, transfer ownership, dispose or export a radioactive source without an appropriate licence from the Authority [4].
(b) Owners of radioactive sources were directed not to engage the services of unauthorized transporter operator.
(c) All application for authorization is to be assessed in term of safety and security.
(d) An inspection is to be conducted to ascertain the applicant's submission and carry out physical verification.
(e) The licensee is to obtain security clearance from the State Service Department and all transport is to be accompanied by armed police.
(f) Transportation of sources is to be between 06:00 and 18:00 [5].
(g) The Authority is to be notified within 24 hours by the licensee for loss of control of sources, unauthorized access to which may have security implication and discovery of unaccounted source.
(h) The major operators in the industry especially in the oil and gas industry were encouraged to bring forth those who transport radioactive sources for them for authorization and this was achieved through series of dialogue.

Since the NNRA hosted the first stakeholder workshop in 2008 and a follow up in 2010, the cases of loss of control of radioactive sources during transportation has been brought to near zero. The level of security consciousness in the transportation of radioactive sources has risen among stakeholders in this practice while the number of licensed transporters have steadily increased from a mere two in the land transport and none before the 2008 workshop as shown in Table 1.

5. CONCLUSION

The NNRA has so far strengthened its regulatory control regime regulating the transportation of radioactive sources in Nigeria. The Regulatory Control Programme, which has been successful implemented by the NNRA over ten years, has resulted in compliance with regulatory requirements by operating organization, giving birth to the maintenance of high level of security of radioactive sources through their life cycle by extension strengthening the weakest link in the chain import–transport–use–transport–export of radioactive sources. This measure has greatly improved the security of radioactive sources and therefore minimized the incident of loss of control during transportation and transit.

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NUCLEAR EDUCATION AND TRAINING AS FUNDAMENTAL PREREQUISITES FOR SUCCESSFUL IMPLEMENTATION OF THE CODE AND THE GUIDANCE IN SMALL 'NON-NUCLEAR' STATES
Example of Montenegro

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Abstract

Successful implementation of international norms on the safety and security of radioactive sources — as summarized in the Code of Conduct on the Safety and Security of Radioactive Sources and its associated Guidance on the Import and Export of Radioactive Sources — requires a number of prerequisites for the State, including adequate legal, institutional, financial, technical and human resources. Among these, it is often taken for granted that necessary knowledge and competence do exist per se. However, this is not always the case — just the contrary, time, effort and resources are frequently wasted because these fundaments are not set solid at first. The state of the matter in Montenegro is discussed, particularly circumstances leading to the establishment of the Centre for Nuclear Competence and Knowledge Management, aimed to be the State's hub of expertise for all radiation and nuclear related issues.

1. INTRODUCTION

Nuclear knowledge and competence represent a broad range of both theoretical and practical achievements of research and experience accumulated in more than hundred years of nuclear field extensive development. It goes from fundamental physical laws of the universe to widespread medical applications for diagnostic and therapy purposes, from nuclear power plants or nuclear weapons to common analytical techniques, from huge internationally operated accelerators to plain household smoke detectors.

However, the need for nuclear knowledge in a society may vary substantially, depending primarily on two factors: its level of general development and whether or not it utilizes (or intends to utilize) nuclear energy for power production.

Successful implementation of international norms on the safety and security of radioactive sources — as summarized in the Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1] and its associated Guidance on the Import and Export of Radioactive Sources (Guidance) [2] — requires a number of prerequisites for the State, including adequate legal, institutional, financial, technical and human resources. Among these, it is often taken for granted that necessary knowledge and competence do exist per se. However, this is not always the case — just the contrary, time, effort and resources are frequently wasted because these fundaments are not set solid at first.

2. SITUATION IN MONTENEGRO

Montenegro is a small, developing ‘non-nuclear’ State (no nuclear installations or fuel cycle elements); the use of radiation sources being modest and limited to ordinary medical and industrial applications. Even though — and taking into account current and near future status of the field — there is (or will be) significant need in nuclear knowledge, which is the case with many (similar) States. It includes the following areas, the list being far from exhaustive (note many being related, directly or indirectly, to safety and security):

- Medical uses of radiation sources, for example diagnostics, radiotherapy, palliative treatment, sterilization (of equipment, blood products and consumables, among others);
- Radiation protection in general, with is various particular aspects, such as dosimetry (personal and environmental), radioactivity control in food and consumables, radon monitoring and control, environmental issues and radioecology, low and intermediate activity radioactive waste management, various analytical and monitoring services;
- Preparedness and response to radiological and nuclear emergency situations;
- Applications in industry, geology, hydrology, agriculture and biochemistry, among others (e.g. non-destructive testing, various gauges, radioisotope labelling and radio-tracers);
- Scientific and educational applications (both nuclear and non-nuclear);
- Safety and security of radiation sources in general, with its various aspects;
- Legislative and regulatory issues, including complying to international safety/security norms and joining international conventions in the field;

- Nuclear forensics and applications of nuclear techniques in classic forensics;
- Combating illicit trafficking of nuclear and radioactive materials;
- Security systems based on X rays or other nuclear methods;
- Introduction of some future topics (e.g. nuclear power for electricity generation, sea water desalination and nuclear fusion);
- Information and communication with the public and media.

There is currently an obvious nuclear knowledge shortage in the country, resulting from unfortunate recent political and economic history of the region, brain drain and attrition, and poor interest of young students for the subject, among other things. Perhaps the most in need are nuclear safety and security related items from the above list. One should, however, note considerable improvements in the past few years, following the reinstallation of State independence in 2006.

The University of Montenegro — the only State university in the country — effectuates practically complete high education in natural and technical sciences. The idea of establishing a university Centre for Nuclear Competence and Knowledge Management (UCNC) [3, 4] was with the intention of:

- Being national centre of competence and expertise in nuclear related issues;
- Acting towards assessing, creating, preserving and transferring nuclear knowledge, according to Montenegro needs;
- Offering consultancies and technical support services to regulatory authorities and stakeholders;
- Being advisory body to the government for nuclear related issues;
- Focal point for dissemination and exchange of nuclear knowledge, in particular with the IAEA and the European Union;
- Promoting nuclear applications for peaceful purposes, in particular medicine and environmental protection;
- Being national radiation protection centre;
- Developing curricula for nuclear related studies at all levels (from elementary education to university degrees);
- Supporting young students and scientists in nuclear related field and facilitate their exchange with reputed institutions abroad;
- Providing proper and timely information and comments for the public and media on relevant nuclear related subjects.

The above goals are supposed to be met through the following scope of UCNC activities, being currently in various stages of implementation:

(a) Organizing a series of training courses on radiation protection for middle medical staff (nurses and technicians) working with radiation sources.

(b) Training courses for medical doctors and engineers (maintenance) working with radiation sources.
(c) Delivering public lectures (also for media) on a series of topics of common interest (benefits and harmful effects of radiation, nuclear energy for electricity production and nuclear research, among other things).
(d) Visiting schools and animating young people for joining studies of nuclear related sciences.
(e) Developing curricula first for postgraduate, then for Bachelor studies on various nuclear related subjects pertinent to Montenegro current and future needs, including:
    - Application of radiation sources in medicine;
    - Radiation protection in medicine;
    - Application of radiation sources in industry;
    - Radiation protection in industry;
    - Dosimetry;
    - Nuclear analytical methods;
    - Radioecology;
    - Legal framework and regulatory control of radiation sources;
    - Radiological and nuclear emergency preparedness and response;
    - Nuclear legislation and international nuclear law.

The UCNC was established in 2009 with support of the IAEA. At the UCNC, we soon realized the need for appropriate nuclear education and consequently took part in the IAEA based International Nuclear Security Education Network (INSEN)[1] from its beginnings in 2010. Preceding this was our active participation in the development of the IAEA Nuclear Security Series No. 12, Technical Guidance, Educational Programme in Nuclear Security [5].

As a result of the INSEN activities, curricula for several nuclear safety and security related courses were developed and courses were introduced (as part of optional courses menu) into postgraduate educational programmes of Applied Nuclear Physic at the Department of Physics, University of Montenegro (in all of them, the Code and the Guidance are listed as recommended literature). Currently, these include:

- Fundamentals of nuclear safety and security;
- Radiation and nuclear security — practical aspects;
- Nuclear forensics;

[1] See http://www-ns.iaea.org/downloads/security/insen-overview2012.pdf and http://www-ns.iaea.org/security/workshops/insen-wshop.asp.

— Nuclear physics for regulators;
— Nuclear knowledge management.

In addition, awareness about nuclear safety and security issues (education and training in particular) rose considerably among academic staff. However, this was not the case (at least not to the same extent) among other stakeholders (regulatory bodies, relevant ministries, police departments and emergency centres, among others) — we are determined to strive for improving that in future.

Perhaps the most difficult task will be to attract more attention for the topic from young students: with interest for natural and technical sciences declining in general in the past 20 years, it represents a broader concern than nuclear education alone. It is reassuring that within last two generations, we are noticing some recovery, both in number and in quality of enrolling students.

Finally, one should distinguish clearly between education and training. Education builds up knowledge, while training develops ability to its practical application; both knowledge and training are necessary for competence. However, training cannot replace education. Training is meaningful only when superposed onto an adequate education. Confusing these terms may lead to a false perception of knowledge and competence (quasi-knowledge/quasi-competence), which will inevitably compromise safety and security.

IAEA assistance to Montenegro in the above sense — through various modalities of its cooperation with Member States — proved effective and welcome. We hope it will continue the same way. With Montenegro in the accession process to the European Union, it is now our double responsibility to provide required education, knowledge and competence for applying international norms and standards in nuclear safety and security in the country, with the Code and the Guidance having their enlightening and pivotal role.

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TRAINING DESIGN FOR PHYSICAL PROTECTION AND SECURITY MANAGEMENT OF RADIOACTIVE SOURCES IN INDONESIA

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Abstract

The Security of Radioactive Sources Regulations was enacted in Indonesia in 2007, and needs to be met three years since the enactment of the regulation. Nuclear facility and medical facilities that have security level A radioactive sources have high potential for malicious use of radioactive sources. Hence, all personnel involved in the security of radioactive sources need to have adequate knowledge and awareness to support security activities. An effective way to achieve the competencies is through training. Physical protection and security management (PPSM) training design in Indonesia has been done under the cooperation of Australian Nuclear Science and Technology Organisation and the National Nuclear Energy Agency of Indonesia (BATAN, Badan Tenaga Nuklir Nasional) since 2010. It was based on the systematical approach to training, which covered the training need analysis (TNA), development of a curriculum and syllabus, development of modules, implementation and evaluation. Training design covered training for BATAN personnel and personnel involved in the medical facilities security Group A. The TNA identified two types of training for BATAN personnel and four types of training courses for four different groups of personnel involved at security Group A medical facilities. The training modules were developed at the Education and Training Center (ETC). PPSM training for BATAN personel have been implemented since 2011 and 71 participants have so far attended. The ETC has provided instruction for the trainers and has been involved in preparing and delivering training materials.

1. INTRODUCTION

The physical protection and security management (PPSM) of radioactive source is greatly needed to ensure security of radioactive source during usage, transportation and storage. To apply PPSM, certain instruments need to be fulfilled, such as regulation, equipment, infrastructure and human resources. In Indonesia, policies on PPSM had been formed and included in Goverment Regulation No. 33/2007 in Radiation Safety and Security of Radioactive Source, and Regulatory Body Regulation (Bapeten Chairman Regulation, BCR)

No. 7/2007 in Security of Radioactive Source. It needs to be met three years after the enactment of the regulation. For equipment and infrastructure, facilities which use radioactive source has to fulfil requirements in those regulations, as well as for human resources. As mentioned in those regulations, the human resource qualities required are responsibility to radioactive source safety and a security guard of the radioactive source with knowledge of radioactive source safety and security of radioactive source.

Nuclear facility and medical facilities that have security Group A radioactive sources, such as teletherapy and blood irradiators, have high potential for malicious use of radioactive sources. Hence, all personnel involved in the security of radioactive sources need to have adequate knowledge and awareness to support security activities. An effective way to achieve the competencies is through training, which requires design.

2. METHOD

PPSM training design in Indonesia has been done under the cooperation of Australian Nuclear Science and Technology Organisation (ANSTO) and the National Nuclear Energy Agency of Indonesia (BATAN, Badan Tenaga Nuklir Nasional) since 2010. Training design has been based on:

— Systematical approach to training, which comproses five stages;
— Training need analysis (TNA);
— Development of curriculum and syllabus;
— Development of modules;
— Implementation;
— Evaluation.

The purpose of TNA is to identify the relevant factor of the facility operation and to identify and define target audiences, course objective and topical learning outcomes, through the questions:

— Whom do you need to train?
— Why do you need to train?
— What experience do they already have?
— What subject matter needs to be learned?
— What skills need to be gained?
— How much time do you have for training?
— What resources do you have/need?

From the TNA, the curicullum and syllabus were developed to meet the course objective and topical learning outcomes. It also refers to the Goverment Regulation.

In supporting the implementation of PPSM training course, the Education and Training Center (ETC) provided training of trainers, which covered teaching style and writing modules, for all of lecturers and instructors involved in preparing and delivering training materials. The lecturers developed the learning aids such as modules and presentations.

The implementation covered the selection of participants and the delivery of materials, exercises and evaluation. The implementation were evaluated in three ways:

(1) Observation by expert;
(2) Evaluation increasing participant knowledge through pre- and post-testing;
(3) Evaluation of course execution with a questionnaire.

3. RESULT AND DISCUSSION

The TNAs have been conducted since 2010 and have identified two types of training for BATAN personnel, security guards of radioactive sources (SGRS) and operators and four types of training courses for four different groups of personnel involved at security Group A medical facilities, which are SGRS, operational staff, managers and response teams (see Tables 1 and 2). Training for the medical facility managers was recommended to be delivered by the regulatory body.

Curriculum and syllabus were developed for each training course based on the objectives (see Tables 3 and 4).

At present, the ETC has already trained 13 lecturers and 3 instructors, of which 4 lecturers and 2 instructors belong to the ETC and the others are guards. The training modules were developed at the ETC. PPSM trainings for BATAN personel have been implemented by the ETC and BATAN since 2011: twice for SGRS and once for operators, which was attended by 71 participants. PPSM trainings for medical facility Security Group A was planned to be implemented in September 2013.

Each course was attended by around 20 participants, allowing for good interaction with the lecturer. In the exercise, the participants are divided into two or four groups, which is a good size to attend the experiment effectively. Exercises related to Security Group B were done using Industrial Radiography Facility at the ETC. The exercises for Security Group A were done using a ^{60}Co iradiator at the Center for Application of Isotope and Radiation BATAN (see Figs 1 and 2).

TABLE 1. TRAINING NEED ANALYSIS RESULT FOR BATAN PERSONNEL

Course title	Goal	Objective	Audience
PPSM for Security Guards of Radioactive Sources (SGRS)	At the end of this course, they will be able to meet their responsibilities under CR7 (Article 15)	Develop a security programme Evaluate the effectiveness of the physical protection system Implement all applicable requirements of CR7	The role of SGRS could be a security manager or a radiation protection officer
PPSM for Operator		Given the knowledge and skills in the area of PPSM to implement security procedures	Operator Technical and maintenance staff Facility security guards

Note: PPSM — physical protection and security management; SGRS — security guards of radioactive sources.

TABLE 2. TRAINING NEED ANALYSIS RESULT FOR GROUP A MEDICAL FACILITIES

Course title	Goal	Objective	Audience
PPSM of Radioactive Sources at Security Group A Medical Facilities for Security Guards of Radioactive Sources (SGRS)	At the end of this course, the SGRS at a security group A medical facility will be able to meet their responsibilities under CR7 (Article 15)	Develop a security programme Evaluate the effectiveness of the physical protection system Implement all applicable requirements of CR7	The role of SGRS could be a security manager or a radiation protection officer
PPSM of Radioactive Sources (PP&SM) at Security Group A Medical Facilities for Operational Staff	Given the knowledge and skills in the area of PP&SM	To implement security procedures at a security group A medical facility	Radiographer (teletherapy operator) Medical physicist Technical and maintenance staff Facility security guards
PPSM of Radioactive Sources at Security Group A Medical Facilities for the Response Team	Given the knowledge and skills in the area of PP&SM	To be capable of providing an effective response to a security incident at a security group A medical facility	Facility security guards Local police
An Introduction to the PPSM of Radioactive Sources (PP&SM) at Security Group A Medical Facilities for the Managers	Given the knowledge in the area of PP&SM	Make the manager aware of radioactive source security culture and how to implement it at a security group A medical facility	Head of department

Note: PPSM — physical protection and security management; SGRS — security guards of radioactive sources.

TABLE 3. PHYSICAL PROTECTION AND SECURITY MANAGEMENT TRAINING CURRICULUM FOR BATAN PERSONNEL

Subject	Duration (hours)	
	SGRS	Operator
BATAN Physical Protection Policy	1	1
IAEA Code of Conduct	1	0
Government regulation	1	1
Radioactive source use	1	2
Source categorization	2	0
Malicious use of sources	1	1
Design basic threat	2	2
Physical protection principles	3	2
Physical protection equipment	4	3
Design and evaluation of PPS based on performance approach	3	3
Design and evaluation of PPS based on prescriptive approach	3	0
Security programme	2	0
Security management	2	0
Experiment — evaluation of PPS (groups A and B)	8	8
Exercise — source security programme — plan and procedures development	5	0
Exercise — emergency response (contingency scenario)	4	0
Discussion of experiment	2	0
Total duration	45	23

Note: PPS — physical protection system.

TABLE 4. PHYSICAL PROTECTION AND SECURITY MANAGEMENT TRAINING CURRICULUM FOR MEDICAL FACILITIES

Subject	Duration (hours)		
	SGRS	Response team	Operational staff
Government regulation	2	1	1
Radioactive source use at medical facilities	1	2	2
Source categorization	2	0	0
Safety radiation	[a]	2	2
Exercise — radiation protection	[a]	2	1
Malicious use of sources	1	1	1
Physical protection principles	4	3	2
Physical protection equipment	3	2	2
Implementation of a PPS based on BAPETEN Chairman Regulation 7	3	2	3
Evaluation of PPS effectiveness	3	2	0
Exercise — evaluation of a PPS	5	0	0
Source security management	2	0	0
Source security programme	2	0	0
Exercise — source security programme — plan and procedures development	5	0	0
Security culture	2	2	2
Exercise — source security procedures implementation	0	4	4
Exercise — emergency response (contingency scenario)	0	0	0
Total duration	35	23	20

Note: PPS — physical protection system; SGRS — security guards of radioactive sources.
[a] optional.

FIG. 1. Experiment: evaluation of physical protection systems.

FIG. 2. Experiment: emergency response.

The first training course was observed by ANSTO and United States Department of Energy (DOE) experts. They gave the comments that overall, the training course was very well organized and delivered. The material in course handbook was detailed and benefited the participants. It appeared to the reviewers that the training course material was consistent with international best practices in the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [1] and other IAEA Nuclear Series Security guides. The level of interest and engagement on the part of the BATAN participants was high throughout the course. The level of engagement reflects personal ownership and adaptation of the training material as well as effective training techniques by the instructors, but some instructors were not clear on what material and key points were to be presented and integrated into the whole course structure. This resulted in duplicating material and material that was not relevant. The result of evaluation by the ETC is shown in Table 5.

TABLE 5. EVALUATION RESULT

Training title	PPSM for Operator	PPSM for SGRS	PPSM for SGRS
Date	25–28 April 2011	13–17 June 2011	26–30 March 2012
No. of participants	22	25	24
Pre-test score	28.13	29.07	27.10
Post-test score	70.40	62.80	60.90
Increasing score[a]	42.27	33.73	33.80
Lecture quality	11 good / 12	15 good / 16	18 good / 18
Instructor quality	4 good / 4	8 good / 8	14 good / 14
Topics/materials: — Goal — Sequence — Satisfy the job — Materials quality — Slide quality — Test — Experimental equipment	7 good / 7	7 good / 7	7 good / 7

Note: PPSM — physical protection and security management; SGRS — security guards of radioactive sources.

[a] Standard quality is satisfied if the increasing score reached 30.

4. CONCLUSION

The PPSM training design identified two types of training for BATAN personnel, SGRS and operators, and four types of training courses for four different groups of personnel involved at security Group A medical facilities and developed its curricula and syllabus. At present, ETC BATAN has already trained 13 lecturers and 3 instructors for PPSM training course and implemented three PPSM trainings, which were attended by 71 participants. The result of evaluation shows that the the training course was well organized and delivered. The ETC has the human resources to conduct training design for the PPSM of industrial radioactive sources.

ACKNOWLEDGEMENTS

Appreciation is given to ANSTO and the DOE for the opportunity in all security of radioactive source activities, especially in workshop on the training design of PPSM.

REFERENCE

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA, Vienna (2004).

WAYS OF BETTER CONTROLLING THE MOVEMENT OF RADIOACTIVE SOURCES THROUGHOUT THE WORLD, INCLUDING IMPORT AND EXPORT CONTROLS, AND THE RETURN AND REPATRIATION OF DISUSED SOURCES

(Session 4)

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RAPPORTEURS' SUMMARY

Session 4: Ways of Better Controlling the Movement of Radioactive Sources Throughout the World, Including Import and Export Controls, and the Return and Repatriation of Disused Sources

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Session 4 consisted of a number of speakers who provided regulatory and industry perspectives on controlling the movement of radioactive sources. The national experiences and practices of Belgium, Canada, France, Georgia, India and the United States of America were described. A representative of the International Source Suppliers and Producers Association also shared industry practices for ensuring safe and secure transport of radioactive sources throughout the world.

A number of issues and ideas were raised during the discussion following the presentations. End-of-life management of sources was discussed, where the idea of States sharing information on exported sources, such as the manufacturers and countries of origin, was suggested as one way by which the number of orphan sources worldwide could be reduced. It was also noted that an end-of-life strategy for sources should be addressed prior to the authorization of an import or export.

On the specific solution of repatriation, it was suggested that further guidance be developed, be it as stand alone guidance or added to the supplementary Guidance. Bilateral and regional cooperation were also raised as one means for effective implementation of repatriation as an end-of-life solution.

Denials of shipment continue to be an issue and in this regard, some participants emphasized the need for harmonized regulatory requirements to facilitate the repatriation of sources and to address transboundary movement of orphan sources. Specifically on the topic of the transboundary movement of contaminated scrap metal, it was noted that an international instrument was needed, and the IAEA indicated that such an effort had been undertaken, but not been supported by all Member States. As a result, and as requested by a 2013 IAEA General Conference safety resolution, the IAEA is about to publish as technical guidance the results of the recent discussions and work toward the establishment of such an international instrument.

The main recommendations from Session 4 were:

(a) Export of radioactive source data from manufacturers should be collected and shared among States.
(b) States should reinforce with their licensees the importance of providing prior shipment notifications, as suggested in the supplementary Guidance.

The following conclusions were also drawn from Session 4:

(a) Harmonizing regulatory requirements worldwide should be considered to facilitate transboundary movement of disused sources and contaminated scrap.
(b) Developing guidance to States for the end-of-life management of sources, including repatriation of sources, should be considered. This guidance could be developed as a stand alone best practices guide or added to the supplementary Guidance.

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ENSURING ONGOING SAFETY AND SECURITY IN THE GLOBAL TRANSPORTATION AND USE OF RADIOACTIVE SEALED SOURCES

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Abstract

Each and every one of us is beneficially impacted by the peaceful uses of radioactive material. They are used extensively in a vast array of industries and in an even wider breadth of applications on a truly global basis each and every day. Currently, more than 35 million nuclear medicine procedures are performed annually around the world using short lived radioisotopes. Cobalt-60 sealed sources are used for external beam radiation cancer treatment, with more than 45 000 treatments per day in some 50 countries globally. In addition, ^{60}Co sterilizes around 45% of all single use medical disposable products and preserves food and sterilizes food packaging materials. Radioactive sources are used in industrial applications to check weld and structural integrity; in industrial facilities for process control; in drug discovery; and in numerous other industrial, agricultural and home applications. Over the past 50 years, the applications and the quantity (activity) of radioactive material shipped has grown significantly, with continued growth forecast for the foreseeable future. The International Source Suppliers and Producers Association represents most of the world's major manufacturers of sealed sources and is a leading non-governmental organization in working with the IAEA and regulators globally to ensure the safe and secure transport and use of these products throughout their life cycle.

Design, manufacture, transport, use and disposal of these products is dependent upon the application and adherence to a consistent and comprehensive series of international (i.e. IAEA) and national, as well as local, safety and security guidelines, regulations and procedures. The movement and use of these goods occurs in all regions of the world, and therefore need to be conducted in a manner which will not adversely impact people or the environment. Industry and regulators have jointly met this challenge so much so that radioactive material shipments and source usage are among the safest of any product. How has this level of performance been achieved? How can we maintain this enviable safety and security record? What challenges continue to persist or are now arising that could adversely impact the sealed source life cycle? The paper will address these questions and, based on practical experience, provide suggestions needed to ensure this industry is able to continue providing reliable, effective, safe and secure transport and use of its products in all parts of the world.

1. INTRODUCTION

Radioactive sealed sources are key to a wide variety of applications globally. Sealed sources have been broadly and extensively used for decades. Their use continues to grow. It is therefore critical that we ensure the ongoing safety and security of the transportation and use of these products.

As with many critical use products, sealed sources require reliable, fast and efficient transport from supplier to end user. Inability to provide reliable, cost and time efficient transport will have a deleterious effect, not only on the industry supplying the product, but even more importantly, on the industry or the public that uses and relies on these products. Since radioactive materials are always decaying, the need for an effective global transortation process is imperative.

The widely varied applications of sealed sources are described below, as are some of the controls which have been established and which have helped to ensure an enviable safety and security record over very many years. This is countered with some of the practical issues affecting the transport of these products today, and some recommendations on how to balance ongoing effectiveness and efficiency of transport with maintenance of the exemplary safety and security record.

We all benefit in some way by the peaceful uses of radioactive sealed sources. Such products have practical applications in medicine, industry, oil and gas discovery and transportation, agriculture, food safety, security as well as in common consumer products. They are found in factories, universities, research centres, hospitals, irradiation facilities, construction sites, oil fields and even in our offices and homes.

In medicine, ^{60}Co sealed sources are used for external beam radiation cancer treatment with more than 45 000 treatments per day provided in some 50 countries around the world. Brachytherapy, which is another form of radiotherapy, involves other isotopes in sealed sources being placed inside or next to the area or tumour requiring treatment, and nuclear medicine products and radiopharmaceuticals are used millions of times per year in the diagnosis and treatment of a multitude of diseases. Further, ^{60}Co is used to sterilize around 45% of all single use medical disposables such as sutures, catheters, syringes, heart valves, artificial joints and around 80% of all surgeons’ gloves. In fact, some specific products used in medical procedures, such as biological materials for transplant, alcohol swabs and sealed devices used in endoscopes, can only be sterilized using ^{60}Co.

Radioactive sources have routine use in industrial applications and in public safety for checking weld integrity, and in radiography and non-destructive testing for assessment of structural integrity of critical infrastructure and equipment including bridges, engines, castings and aircraft. In many industrial facilities, sealed sources are used in process control for such things as level, thickness or density gauging. Further, moisture measurement in soil is critically important in the planning and construction of buildings and in such infrastructure projects as highways or bridges, and in oil well logging, and chemical or petrochemical refineries. Finally, sealed sources are routinely used in the security industry for detecting explosives, drugs, toxic chemicals or gases. These sources may exist in a fixed setting in the factory or in mobile equipment transported to the point of use. In addition, tens of millions of homes and businesses around the world which incorporate smoke detectors as part of their safety and security programmes are also beneficiaries of the sealed source industry.

The International Source Suppliers and Producers Association (ISSPA) is an industry association, founded in 2005 and comprised of 16 international member companies from 9 States, which are engaged in the manufacture, production and supply of radioactive sealed sources or equipment that contain radioactive sealed sources as an integral component of the radiation processing or treatment system, device, gauge or camera. ISSPA provides a global voice for the industry and is a recognized non-governmental organization (NGO) of the IAEA. It actively participates as a member of many IAEA technical meetings, consultancies, working groups, conferences, standards committees, the Nuclear Security Guidance Committee and steering committees. This participation helps provide a practical and global approach to the development, implementation and application of international guidelines and ultimately national regulations with respect to the safety and security of radioactive sealed sources. In addition, ISSPA participates in other international and United Nations organizations — the International Air Transport Association (IATA), the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) — and in national as well as local meetings where issues impacting and impacted by sealed sources are in review.[1]

2. HOW IS SAFETY AND SECURITY MAINTAINED?

Shipments of sealed sources occur daily by all modes of transport through a wide variety and size of carriers, and throughout ocean, road, and air and border ports globally. The vast majority of all these movements occur routinely, on time and without issue. The transportation of radioactive materials is highly regulated at the international level through three United Nations organizations: the IAEA, the ICAO and the IMO. Based on these international standards,

[1] Membership and details regarding ISSPA can be found at http://isspa.com.

regulations are promulgated and applied at the national level by such competent authorities as a State's nuclear or transport regulator. Further, State, provincial, municipal or local regulations may separately or jointly govern the movement of these products around the world. Finally, ports (air, land border or sea) through which these products pass will also institute controls to which these products, in transport, are required to abide. The level of control and the regulations to which radioactive sealed sources are required to adhere is therefore highly specific and highly integrated.

Since 11 September 2001, these regulations, which primarily focused on safety, have been supplemented with globally instituted security enhancements. For example, the IAEA published the Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1], which urged all IAEA Member States to follow the guidance contained in the Code and to make a political commitment to the Code. A key objective of the Code was:

— To assist States in their development, harmonization and implementation of national policies, laws and regulations to achieve and maintain a high level of safety and security of radioactive sources;
— To prevent unauthorized access or damage, loss, theft or unauthorized transfer of sources;
— To mitigate or minimize the radiological consequences of any accident or malicious act involving such sources.

In addition, the IAEA published IAEA Nuclear Security Series No. 9, Security in the Transport of Radioactive Material [2], in 2008. The objective of this guide is to assist Member States in implementing, maintaining and enhancing a nuclear security regime to protect radioactive materials, while in transport, against theft, sabotage or other malicious acts that could, if successful, have unacceptable radiological consequences. Further, at a national level, States have implemented regulations which mandate:

— The development and implementation by shippers and carriers of transportation security plans and programmes;
— Personnel security checks;
— In the United States of America, specific requirements via safeguarded information;
— Significant administrative controls applied to or proposed to be applied to the vast majority of radioactive material shipments — both sources and nuclear medicine products.

Sealed sources shipped by air are typically restricted to products having lower activity, while sources with high activity are shipped by road, rail and sea. While all sources are shipped in accordance with transportation security and safety regulations, the larger the source or the greater the activity, the more specific and stringent the regulatory requirements applicable.

ISSPA focuses on ensuring there is an ongoing and beneficial use of radioactive sealed sources and promotes continuous improvements in the safe and secure design, use, transportation and life cycle management of sealed sources. Its mission is to ensure the use of radioactive sources continues to be regarded by the public, media, legislators and regulators as beneficial.

In support of its mission, ISSPA has developed a Code of Good Practice to which all members comply. This code covers such areas as regulatory compliance, quality management, service and device design, manufacturing, sales, distribution, tracking, user support and source life cycle management. The Code of Good Practice helps to ensure industry maintains safety and security in all aspects of business and helps to ensure that compliance with applicable regulations is a minimum standard.

Further, given that industry is shipping radioactive materials throughout the world on both cargo and passenger conveyances, or in the courier network, controls on the containers used to carry these products are highly specific and also highly regulated. The containers used to carry radioactive materials can be segregated into two categories: Type A for small activity shipments and Type B for larger activity shipments. Regulatory controls exist for the testing, safety analysis report completion and review, and licensing and registration of these containers, before their availability for use.

Given the highly and tightly controlled environment in which the processing, preparation, shipment and use of these radioactive products occurs, it is easy to see how the IAEA stated that “over several decades of transport, there has never been an in-transit accident with serious human health, economic or environmental consequences attributable to the radioactive nature of the goods” [3]. This quote is still valid today. When conducted in compliance with the existing regulatory framework, the transport of these products, undeniably critical to society and important to the global economy, is extremely safe and secure.

3. ISSUES IMPACTING INDUSTRY

Controls in place to assure sealed source safety and security in use and in transport have had and continue to promote exemplary performance. This does not, however, automatically mean that there are no issues for the industry. Industry is facing distribution challenges in various parts of the world. These are related to concerns about radiation, increased regulatory burden associated with tracking, security and financial surety exacerbated by competing or conflicting regulations, regulatory agencies and regulators. Further, the long standing issue of denials of shipment continues in several regions of the world.

There are instances when, even though all regulatory controls and requirements are met, the regulator, port, carrier or handlers, among others, refuse to carry sealed sources or allow them into or through their jurisdiction. In fact, the IAEA defines denial of shipment as a refusal to carry or allow a shipment of radioactive material though it conforms to all applicable regulations. In other words, from a regulatory safety and security perspective, failure to comply with all relevant international and national regulations **cannot** lead to denial reporting/ notification.

Denials of shipment are significant, affecting the public and industry alike — specifically suppliers, consumers, industry, government, construction, patients, carriers and all others impacted by the inability to effectively ship or receive, and ultimately, use these products. In addition, the other end of the life cycle is also adversely affected, since denials will adversely impact the ability to transport the spent or expired sources back to the manufacturer or to the waste disposal site for final disposition.

Although denials are occurring globally, they tend to be concentrated in specific geographies, based on origin of supply, supply chain accessibility and capability, available routings to customer sites, and type of source being moved. Products affected vary from small check sources or sources used in smoke detectors to higher activity sources such as those used in medical disposable product sterilization and transported in heavily shielded containers. In addition, nuclear medicine radioisotopes and radiopharmaceutical products (often in mCi activity quantities) are adversely affected. The ability to predict where and when denials will occur is difficult since changes which lead to denials are random and vary from one geographical area to another and from one time to another. The current global economy and increased security environment in which we live and work are additional factors which preclude our ability to determine when or where denials may occur.

4. WHAT IS CAUSING DENIALS?

The IAEA, together with the ICAO and the IMO, has conducted significant research into the cause of denials and have identified five reasons:

(1) Negative perception about radiation due to lack of awareness and information about the industry;

(2) Concerns about the cost and extent of training required of those who handle radioactive materials;
(3) Multiplicity and diversity of regulations governing the handling, use and transport of these products;
(4) Lack of harmonization between governments of these regulations which should be international and consistently applied. The end result of reasons (iii) and (iv) is that there are duplicate, overlapping and sometimes contradictory regulatory requirements;
(5) Lack of outreach and lack of public awareness about the needs and applications of radioactive materials.

5. WHAT IS BEING DONE?

Significant effort and actions have been underway since 2006 to deal with denials, spearheaded by the IAEA International Steering Committee on Denials of Shipment of Radioactive Material (ISCDOS). The eighth, and final, meeting of the ISCDOS, under the IAEA, was held in June 2013. It is now transitioning to the Inter-Agency Group (IAEA, IMO, ICAO, United Nations Economic Commission for Europe and World Health Organization) where a Denials Working Group comprised primarily of past ISCDOS Chairmen and of some IAEA Transport Safety Standards Committee (TRANSSC) members will promote and continue the efforts to mitigate denials. A close integration with TRANSSC will be maintained to push new and additional efforts forward. Some of the initiatives to support the ongoing ISCDOS Action Plan include:

(a) Awareness:
- Denials database development, trend identification and communication to industry globally via national focal points (NFP) and Member States (to ensure magnitude of denials and examples are fully understood);
- Developed a website for providing information required for submitting denial reports;
- Established a data base of national and local competent authorities.

(b) Training:
- Developed an e-learning package for Class 7 dangerous goods;
- Developed an instructional video which overviews the uses and shipping requirements of radioactive material, the regulatory and safety requirements for transporting such material, and the safety record of such carriage;

— Participation at conferences and opportunities to communicate denial issues with organizations and conferences globally.

(c) Communication:
- Developed fact sheets for key radioactive materials in commerce;
- Worked with manufacturers to educate them on the denials issue and gain their involvement and participation.

(d) Lobbying:
- Attending and articulating the denial issue in other United Nations organizations' meetings to 'de-mystify' the use and transport of radioactive materials and to discuss issue and impact of denials;
- Identified stakeholders who are key to the sustainability of radioactive material transport;
- Developed an outreach programme which will positively influence and educate stakeholders;
- Held regional meetings involving all stakeholders.

(e) Economic:
- Identified typical costs incurred in the shipment of radioactive materials and comparison against other dangerous goods in transport;
- Identified administrative burdens and how they impinge on sustainability, specifically regarding impact on those denying shipment;
- Determined administrative changes that would provide a more balanced view of Class 7.

(f) Harmonization:
- Identifying all regulations globally that impact transport of radioactive materials, analyse for inconsistencies;
- NFP and regional network initiatives;
- Examined interface and overlap between regulations;
- Proposed methodology for reduction of overlaps between regulations.

Support of the ISCDOS Action Plan was provided as an outcome of the 2011 International Conference on the Safe and Secure Transport of Radioactive Material. Arising from this meeting, the IAEA identified eight specific areas of focus for future work by the IAEA. These include:

- Harmonization;
- Denial of shipment;
- Regulatory development process;
- Safety requirements and security recommendations;
- Member State implementation and industry compliance;
- Emergency response;

— Communication;
— Regional coordination.

6. SUGGESTED NEXT STEPS

Industry actively participates both in self-assessment and continuous improvement in all aspects of its sealed source business. Industry also integrates closely at all levels in the regulatory development and implementation process. From these various perspectives, industry suggests that the following be considered in order to optimize future effectiveness and efficiency of sealed source transport and use:

(a) Harmonization of security requirements and regulations on a global basis.
(b) Where conflicts or inconsistencies exist now, move towards an agreed upon set of requirements among Member States.
(c) The IAEA prepares a master list of all security requirements existing on a global basis associated with radioactive material transport.
(d) As per ISCDOS, establish (with existing or new) NFP type contact in each Member State and regional coordinators to whom issues with security are addressed and managed.
(e) Recognition of the significant experience and the integration of safety and security requirements in radioactive material transport. Changes in regulations or procedures and processes should only be made where such changes are required based on risk determination (i.e. no change simply for sake of change).
(f) Recognition of source and source container integrity and positive safety and security experience over decades of use.
(g) Recognition of practical limitations of individual source tracking (i.e. radio frequency identification) and package tracking.
(h) Integrate with the industry to provide assessment of practicality of proposed regulatory requirement from a shippers' and a shipping perspective.
(i) Integration of other organizations (i.e. customs) where their involvement ties into proposed security changes.
(j) Provision for flexibility in securely handling disused and spent sources.
(k) Recognition of sealed source end use and activity shipped when considering any changes to existing security measures.

These recommendations follow in part from the positive safety and security experience this industry has developed and integrated over the years and, where possible, ties in with other initiatives (often transport safety related) that the IAEA introduced in the past.

7. CONCLUSION

The ability to effectively and efficiently ship radioactive sealed sources, medical isotopes and other radioactive materials is imperative for the industry producing them, and equally important for the industry and public who rely on them for health, safety, security and commercial reasons.

The global sealed source industry has a long history and an equally long and impressive safety and security record. It has worked hard to earn this enviable position. In conjunction with the broad and comprehensive regulatory environment — international, national (Member State) and local — the partnership between industry and regulators at all levels is strong and, potentially, unparalleled globally. The integration of industry with government and regulators helps to ensure that new or modified regulations or requirements consider and often incorporate industry best practices, and while ensuring safety and security during transport and use, generally work well to help maintain effectiveness and efficiency. Regulatory compliance as the minimum standard is the cornerstone of ISSPA member companies' regulatory philosophy. Additional efforts, a code of good practice and an ability to effectively work at all levels of the regulatory setting process, help to ensure industry's reputation is maintained.

There are some issues that have an adverse impact on the ability to move product but the joint efforts and the willingness to work together to find workable solutions, is not only impressive but imperative. Some recommendations have been provided in this paper, which we feel will help foster the joint ability of industry, government and international bodies to ensure ongoing safety and security in the global transportation and use of radioactive sealed sources.

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REGULATING THE TRANSBOUNDARY MOVEMENT OF RADIOACTIVE SOURCES

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Abstract

Since adoption in 2004, the United States Nuclear Regulatory Commission (NRC) has worked to fully implement the Code of Conduct on the Safety and Security of Radioactive Sources and the Guidance on the Import and Export of Radioactive Sources. By their very nature, import and export provisions may have profound transboundary effects and thus harmonization between different States' regulatory regimes becomes extremely important in the safe and secure movement of these radioactive sources.

1. INTRODUCTION

Under the Atomic Energy Act of 1954, as amended, and the subsequent Energy Reorganization Act of 1978, the United States Nuclear Regulatory Commission (NRC) was granted the authority to regulate the export of nuclear equipment and material. The regulations implementing this statutory authority can be found in 10 CFR Part 110. Before it was adopted, the United States of America had made a political commitment to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1] and the supplementary Guidance on the Import and Export of Radioactive Sources (Guidance) [2], and the import and export of almost all by product material contained in sealed sources was authorized by the NRC general licences in 10 CFR 110.23 (export) and 110.27 (import). After the United States of America made a political commitment to the Code and the Guidance, the NRC amended the import/export regulations in Part 110 to include the Category 1 and 2 radionuclides of concern by adding appendix P. By amending the regulations for inclusion, the NRC shows the commitment that the US Government has to the provisions contained in the Guidance. The US political commitment to the Code (and the Guidance) became a legal commitment for US licensees with the promulgation and enactment of the Energy Policy Act of 2005.

2. DEVELOPMENT OF REGULATIONS

The United States of America was intimately involved in the creation of the Code and the Guidance. To show the strong commitment to the principles contained in these documents, the US Congress passed legislation (Energy Policy Act of 2005) that included the mandate to develop regulations to implement the guidance set forth in the Code and the Guidance. As the lead regulatory authority, the NRC went through the rulemaking process to include the requirements laid out in the Code and the Guidance into the regulations in 10 CFR Parts 30–39 (domestically for the Code) and Part 110 (transboundary for the Guidance). This paper focuses on the US application of the Guidance carried out through the NRC's implementation of Part 110 Export and Import of Nuclear Equipment and Material.

Before 2005, most Category 1 and 2 radioactive sources were included in the general licence for by product material (10 CFR 110.23). A general export licence is issued by order of the regulation. There is no application process or paper documents issued to exporting entities. However, as part of the requirements in the regulations, exporters are to comply with the regulations of other Government agencies (e.g. Department of Transportation for shipping requirements) and need to be aware of the States listed as 'embargoed destinations' (10 CFR 110.28), since a general export licence cannot be used for those States (which are currently Cuba, the Islamic Republic of Iran, Iraq, the Democratic People's Republic of Korea, Sudan and the Syrian Arab Republic). Additionally, the 110.23 general export licence requirements place some restrictions on the 'restricted destinations' in 10 CFR 110.29 (currently Afghanistan, Andorra, Angola, Djibouti, India, Israel, Libya, Myanmar and Pakistan). These regulations in Part 110 are updated fairly often according to changes in US international policy and are dictated by the Department of State.

Upon passing of the Energy Policy Act, the NRC added an appendix to the regulations in 10 CFR Part 110. This new appendix P added the Category 1 and 2 thresholds (from the IAEA categorization of sources) to the export regulations and required specific licences to be issued for the import and export of all radioactive sources above the Category 2 threshold. Additionally, the United States of America chose to exercise the aggregation option highlighted in the Code (and Guidance), so when Category 3 sources aggregate to a Category 2 quantity for shipment, a specific export licence is required. Also of note is that when Category 2 sources aggregate to a Category 1 quantity, consent is required (even though if shipped individually, consent would not be needed).

3. CURRENT IMPLEMENTATION OF PROVISIONS IN THE GUIDANCE

In 2010, after the implementation of extensive post 9/11 domestic enhancements in the safety and security of sources, the NRC made a significant change to the regulations in Part 110 to return to general licensing for all imports of radioactive sources. In going from specific to general import licensing, the pre-shipment notification time increased from 24 hours to seven days before shipment. This provides enough time for NRC staff to ensure that the US recipient is authorized to receive and possess the isotope and quantity specified in the shipment. If the recipient does not have the appropriate authorization to possess the material, the seven days provide time for staff to interact with the foreign regulator to stop the shipment if necessary. The US licensee is responsible for making this seven day pre-shipment notification and therefore needs to know the shipment date from their foreign customer in time to meet the NRC deadline.

Unlike the seven day pre-shipment notifications for imports, exports of Category 1 or 2 quantities only require 24 hours advanced notice. The information required in pre-shipment notifications is found in Section 110.50 and is identical to that found in the Guidance. Along with the data elements, the exporter is required to include a copy of their foreign customer's material possession licence. These notifications and supporting documents are checked by the NRC, and staff have found it very helpful when these documents are written in English (or accompanied by an explanation of the foreign licence in English.) The NRC typically receives approximately a dozen of these export pre-shipment notifications per day.

In the last few years, the NRC has made a concerted effort to evaluate the import and export pre-shipment notifications and has pursued enforcement action according to agency policy for shipments in which notifications were not made or did not meet the reporting deadline. Enforcement actions have also proceeded on cases in which:

— Exporting companies did not obtain an export licence to ship to embargoed destinations.
— Companies shipping ^{241}Am, ^{235}Np and ^{237}Np under the general licence had not made the annual report.
— Importing companies had not obtained the correct domestic licence in order to be able to use the general import licence.

In response to the cited and non-cited violations issued by the NRC, most licensees have become more familiar with US export controls and have implemented corrective action plans to avoid recurrence.

The designation of a Point of Contact (PoC) is key for the purposes of imports and exports of Category 1 sources, since a foreign government regulator needs to grant consent. The NRC recognizes the importance of a responsive, working level PoC that fully understands the roles and responsibilities included in the job description. The IAEA list is a valuable tool in making international contacts, although the currency of the list is only as good as the input provided by Member States. In some cases, the NRC has had to use other mechanisms to contact the regulatory body, such as consulting lists of Code of Conduct meeting attendees, informal consultation with other regulatory authorities and interaction with the desk officers in our Office of International Programs who have been assigned specific States. As a repository for the PoC list, the IAEA updates it when that information becomes available but it is the responsibility of Member States to communicate changes through normal, official channels (e.g. the mission).

The NRC supports the international implementation of the Code and the Guidance through interactions with foreign counterparts. For example, in July 2011, the NRC sponsored a meeting held at the IAEA for States that had not yet made political commitments to the Code or the Guidance. The intent of the meeting was to provide first hand experience on how some States have implemented the documents and to determine some of the barriers States have in making commitments to the Code or the Guidance. As a result of this meeting, there seemed to be a marked increase in Member State commitment to the Code and the Guidance. As of June 2013, 117 States had made political commitments to the Code and 79 to the Guidance. Although the number of political commitments are important, making that commitment is just the first step. There is still a long way to go for States to implement the Code and the Guidance, working toward an internationally harmonized approach.

The NRC has used Memoranda of Cooperation to enhance communication with frequent trading partners. The arrangements that the NRC has entered into with counterpart regulatory authorities in Australia, Brazil, Canada and Mexico have enhanced relationships and has resulted in more frequent personal interactions between licensing staffs to help ensure that our licensees are engaging in appropriate actions. Additionally, the NRC has exchanged import and export licensing information with regulatory counterparts in Singapore, Thailand and the United Arab Emirates (beyond the States in which a Memorandum of Cooperation has been achieved).

4. CONCLUSION

The NRC has played an active role in the development of the principles in the Code and the Guidance and implementation of those principles over the last ten years. The NRC continues to assess domestic implementation and make improvements as necessary to enhance the safety and security of radioactive sources. The United States of America looks forward to a more harmonized, global implementation of the principles of the Code and the Guidance in the future.

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IAEA-CN-204/222

CANADA'S NUCLEAR SAFETY COMMISSION'S IMPLEMENTATION AND BEST PRACTICES OF IMPORT AND EXPORT CONTROLS FOR CATEGORY 1 AND 2 RADIOACTIVE SOURCES PURSUANT TO THE IAEA CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES AND ITS SUPPLEMENTARY GUIDANCE ON THE IMPORT AND EXPORT OF RADIOACTIVE SOURCES

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Abstract

The paper presents the Canadian approach and experiences to the implementation of import and export controls pursuant to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code) and its supplementary Guidance on the Import and Export of Radioactive Sources. The paper outlines the major Canadian Nuclear Safety Commission regulatory controls implemented to meet the import and export control provisions of the Code and to manage the export and import of Category 1 and 2 radioactive sources, discusses implementation issues and identifies a number of challenges and best practices that warrant discussion by Member States to promote more effective international harmonization of import and export controls.

1. INTRODUCTION

Canada is a global leader in the manufacture, supply and export of Category 1 and 2 radioactive sources that are subject to the provisions of the Code of Conduct on the Safety and Security of Radioactive Sources (Code) [1] and its supplementary Guidance on the Import and Export of Radioactive Sources (Guidance) [2]. As such, the Government of Canada continues to support the establishment and maintenance of an effective, efficient and harmonized international regime to ensure the safety and security of such sources in keeping with Canada's political commitments to the Code and the Guidance made in 2004 and 2005, respectively.

Under the Nuclear Safety and Control Act (NSCA), the Canadian Nuclear Safety Commission (CNSC) is responsible for controlling the export and import of nuclear substances, including Category 1 and 2 radioactive sources. The CNSC is also responsible for implementing Canada's political commitments to the Code and the Guidance. Through its role in implementing export and import control measures, the CNSC enhances national and international safety and security by ensuring that only authorized persons are recipients of Category 1 and 2 radioactive sources. The CNSC's import and export control programme is consistent with the Code and the Guidance, which have the following objectives:

- Achieving a high level of safety and security regarding Category 1 and 2 radioactive sources;
- Reducing the likelihood of accidental harmful exposure to Category 1 and 2 radioactive sources or the malicious use of such sources to cause harm to individuals, society and the environment;
- Mitigating or minimizing the radiological consequences of any accident or malicious act involving Category 1 and 2 radioactive sources;
- Facilitating international cooperation and promoting harmonized approaches.

This paper provides a summary of the import and export control programme implemented by the CNSC with respect to Canada's political commitment to the Code and the Guidance.

2. CNSC IMPORT AND EXPORT CONTROLS PROGRAMME FOR RISK SIGNIFICANT SEALED SOURCES (IAEA CATEGORY 1 AND 2 RADIOACTIVE SOURCES)

Prior to the 1 April 2007 implementation of an enhanced CNSC import and export control programme, the CNSC reviewed and adapted its regulatory processes to ensure conformance to paras 23–29 of the Code and the Guidance.

The enhanced CNSC import and export control programme for Category 1 and 2 radioactive sources is fully consistent with the provisions of the Code and the Guidance. Canadian exporters are required to apply for and obtain an export licence from the CNSC prior to exporting Category 1 and 2 radioactive sources. The programme encompasses licensing, compliance, prior shipment notifications to importing States, post-shipment verifications, State to State requests for import consent to import Category 1 radioactive sources, the establishment of bilateral administrative arrangements, and the confirmation of receipt of radioactive sources as negotiated in several bilateral administrative arrangements.

Since the implementation of the enhanced programme in April 2007, the CNSC has authorized the export of more than 8.5 million TBq of Category 1 and 2 radioactive sources to over 85 States. The CNSC does not issue specific licences for the import of Category 1 and 2 radioactive sources, but does implement additional regulatory controls on imports consistent with bilateral notifications required under the Code and the Guidance.

3. ISSUANCE OF EXPORT AUTHORIZATIONS UNDER THE NUCLEAR SAFETY AND CONTROL ACT

Prior to April 2007, the export of Category 1 and 2 radioactive sources was authorized under a general authorization through possession and use licences. In order to satisfy itself that the radioactive source recipient is authorized to possess the source in accordance with domestic laws and that the importing State has the appropriate technical and administrative capability, resources and regulatory infrastructure needed to effectively manage the radioactive source, the CNSC made it a requirement for licensees to obtain a transaction specific export licence issued pursuant to the NSCA for Category 1 and 2 radioactive sources. Implementation of this requirement did not require amendment to the NSCA or its regulations. Several sections of the NSCA are relevant to the issuance of export licences and subsequent compliance:

— Section 24 allows the CNSC to establish export licences for authorizing the export of Category 1 and 2 radioactive sources.
— Section 26 makes it a requirement that a licence be required for export of Category 1 and 2 radioactive sources.
— Section 24(5) allows the CNSC to impose any licence condition necessary for the purpose of the NSCA.
— Section 37 grants authority to a designated officer to issue on export licence.
— Sections 29–36 allows for designation of inspectors for verifying compliance with the NSCA.

4. EXPORT CONTROLS

4.1. Assessment of applications to export Category 1 radioactive sources

The export of Category 1 and 2 radioactive sources requires regulatory assessment and control to ensure the safety and security of radioactive sources consistent with the objectives, and provisions of the Code and the Guidance. The CNSC conducts a comprehensive assessment of all applications to export Category 1 and 2 radioactive sources. The assessment includes a review of the importing State's capacity to effectively manage Category 1 and 2 radioactive sources which includes requirements of IAEA thematic safety areas 1 and 2. A review of the end user authorization to receive, possess and use the radioactive source is conducted. This review also includes an end use assessment to ensure that the radioactive source to be exported meets the intended end use specifications. A review of responses to the IAEA Guidance Questionnaire is also completed to complement the full State assessment conducted by the CNSC.

Upon receipt of an application to export a Category 1 radioactive source, the CNSC initiates a process to request the import consent from the importing State authority pursuant to para. 6 of the Guidance. The IAEA form Request to the Importing State for Consent to Import Category 1 Radioactive Sources is submitted by the CNSC to an importing State authority regardless of whether or not the importing State has made a commitment to implement the provisions of the Code.

The CNSC will only issue an export licence once it has satisfied itself that all required supporting documentation has been submitted and reviewed, and is assured that the sources to be exported will be managed in a safe and secure manner by an authorized end user.

4.2. Assessment of applications to export Category 2 radioactive sources

The application review process for Category 2 radioactive source exports follows the same approach and considerations as indicated for Category 1 radioactive sources, with the exception that import consent is not requested. Nonetheless, the CNSC may seek import consent under certain circumstances where multiple Category 2 sources are exported as a single shipment and remain in that configuration during use of the sources (e.g. ^{60}Co Gamma Knife sources) and where the aggregated total quantity shipped will exceed Category 2 levels. In those situations, the transaction is considered in the same light as a Category 1 export and subjected to the same approval measures.

As with Category 1 radioactive sources, the CNSC will only issue an export licence to the exporter once it has satisfied itself that all supporting documentation has been submitted and reviewed, and it is assured that the sources to be exported will be managed in a safe and secure manner by an authorized end user.

4.3. End-of-life cycle management considerations prior to authorization of export

To provide assurances that exported Canadian origin radioactive sources will be managed throughout their life cycle, the CNSC considers the importing State’s capacity to manage effectively the radioactive source throughout the life cycle, including end-of-life management. Where it becomes apparent that a State is not able to manage a radioactive source throughout the life cycle, a recommendation to deny the export may be made. Cases of this include use of radioactive sources in a practice that will knowingly cease with the operation being decommissioned with no strategy for end-of-life management of the source.

5. COMPLIANCE

5.1. Shipment notifications issued by Canadian exporters

The issuance of a prior shipment notification and a post-shipment verification are key compliance elements in the CNSC export and import control programme. Exporters are required to provide a prior shipment notification as a condition of their export licence to the importing State authority and the CNSC at least seven calendar days prior to the intended shipping date, and a post-shipment verification two business days following export. Providing prior shipment notification to the importing State authority allows the authority the opportunity to review the pending export prior to it leaving Canada and, if necessary, request that the export not proceed due to regulatory or security concerns.

Prior shipment notification is a requirement imposed on all Canadian licensees and is consistent with paras 9 and 12 of the Guidance. All notifications submitted by Canadian licensees are acknowledged, entered into a licensing database and reviewed for compliance with the issued export licence. Items of potential non-compliance that arise from the prior shipment notifications are addressed prior to the export from Canada.

To assist the Canadian licensees in submitting the required notifications, the CNSC includes the relevant point of contact information for the respective importing State as an annex to each licence and also includes the information requested in paras 9 and 12 of the Guidance.

5.2. Prior shipment notifications received by the CNSC for import of Category 1 and 2 radioactive sources into Canada

For all imports of Category 1 and 2 radioactive sources into Canada, it is an expectation of the CNSC that prior shipment notification will be provided to the CNSC by the exporting State authority or exporting facility consistent with paras 9 and 12 of the Guidance.

Upon receipt of a prior shipment notification from the exporting State authority or exporting facility, the CNSC will review the information to verify that the Canadian recipient is authorized to receive the radioactive source under their possession licence. Should any discrepancies be identified, the CNSC will contact both the importing and exporting facilities and/or the exporting State authority for follow-up action. All import notifications received by the CNSC are acknowledged to provide confirmation of receipt. To facilitate receipt of the notifications, the CNSC established a generic email account accessible by CNSC staff involved in the import and export control programme.

Under the terms and conditions of the importing facility's possession and use licence, the Canadian licensee is required to enter the source data into the National Sealed Source Registry (NSSR) through the Sealed Source Tracking System (SSTS) within 48 hours of receipt.

5.3. Inspections and regulatory actions

The CNSC conducts regular compliance inspections of its licensees in relation to the import and export control programme. The purpose of the inspections is to verify compliance with export licensing requirements, reconcile CNSC records relating to exports of Category 1 and 2 radioactive sources by the licensee and ensure that exports of Category 1 and 2 radioactive sources have been conducted in full compliance with Section 26 of the NSCA. The inspections are conducted pursuant to Section 30 of the NSCA.

The inspections focus on an audit and review of documentation related to the export of Category 1 and 2 radioactive sources. Documents typically reviewed include:

- Sealed source export licenses issued by the CNSC;
- Prior shipment notifications;
- Post-shipment verifications;
- Shipping documents;
- Customs documents;
- Exporting facility source inventory records;

— Exporting facility source production records;
— Procedures and training records.

A report of the inspection is provided to the licensee. The report details the inspection observations and findings, the analysis of the findings and conclusions drawn from these analyses. These conclusions form the basis for regulatory actions and recommendations for follow-up.

6. IMPORT CONTROLS

The CNSC currently does not issue transaction specific licences for the import of Category 1 and 2 radioactive sources. CNSC licensees that are authorized to possess Category 1 and 2 radioactive sources may import such sources consistent with any general import authorization for those sources that exists in their possession licences. As per the possession licences, the CNSC licensees need to report receipt of the imported Category 1 and 2 radioactive sources to the NSSR through the SSTS. The web based tracking system was established in January 2006 as part of Canada's implementation of the Code.

Category 1 radioactive sources imported into Canada are subject to prior import consent by the CNSC. All radioactive source imports are expected to be preceded by prior shipment notifications from the exporting State authority or the exporting facility.

Failure to seek import consent and to provide prior shipment notification undermines the effectiveness of the programme and can adversely affect the safety and security measures prescribed by the Code and the Guidance.

7. OUTREACH DOCUMENTATION AND APPLICATION TOOLS

To further assist Canadian exporters and regulatory counterparts in understanding the implementation of Canadian export and import controls, the CNSC published INFO-0791, Control of the Export and Import of Risk-Significant Radioactive Sources [3]. In addition to INFO-0791, the CNSC created an on-line application form in PDF writable format and detailed instructions for its completion for the Canadian exporters of Category 1 and 2 radioactive sources.

8. BILATERAL ARRANGEMENTS

Consistent with para. 20(n) of the Code and paras 5, 9 and 12 of the Guidance, the CNSC establishes bilateral administrative arrangements with authorities in other States for the export and import of Category 1 and 2 radioactive sources. The CNSC enters into these arrangements pursuant to paras 21(1)(a) and (f) of the NSCA. To date, the CNSC has established 12 arrangements for the import and export of radioactive sources.

The purpose of the bilateral arrangements is to establish measures to ensure that exports and imports of radioactive sources between Canada and the other State are conducted in a manner consistent with requirements under the Code, Guidance, NSCA, and respective laws and regulations of the other State. The arrangements assist in harmonizing regulatory approaches in authorizing imports and exports of radioactive sources, facilitate the sharing of regulatory information related to imports and exports of radioactive sources and enhance international commitments related to the safety and security of radioactive sources.

Within the international community, it has been recognized that the use of such bilateral arrangements is an effective means to foster harmonized implementation of the Code and the Guidance and cooperation in import and export controls for radioactive sources.

The establishment of bilateral arrangements for facilitating greater international harmonization of controls was regarded as a good practice by the IAEA Integrated Regulatory Review Service and CNSC management have responded to the IAEA that this practice will continue in support of the CNSC's implementation of the Code and the Guidance.

9. EXPERIENCE AND LESSONS LEARNED

Since implementation of the enhanced import and export control programme in 2007, the CNSC has authorized the export of more than 8.5 million TBq of Category 1 and 2 radioactive source exports from Canada and has interacted with over 85 States during the approval process. As a result, the CNSC has gained considerable experience related to the implementation of the Code and the Guidance and has observed many challenges, best practices and lessons learned.

The following outlines the main areas of concern, with potential solutions to increase the harmonization of the import and export control provisions of the Code and the Guidance.

9.1. Implementation

The experience of the CNSC through its interactions with over 85 States is that the level of implementation of the Code and the Guidance continues to be uneven and in some instances appears inconsistent with provisions of the Code and the Guidance. The issue is further compounded when dealing with States that have established multilateral import and export arrangements within an open border concept that has not taken into account the Code and Guidance provisions.

In order for the export control provisions of the Code and the Guidance to be implemented in a harmonized manner, all States that have made a political commitment to the IAEA are encouraged to implement them consistently.

9.2. Importing State end-of-life management strategy

In support of efforts to ensure continuous control of radioactive source throughout their life cycle, the CNSC examines the importing State's long term strategy and end-of-life management for radioactive sources as part of the overall State assessment prior to authorizing exports. Efforts to obtain this information remains challenging for States that do not have an adequate regulatory framework and information received occasionally conflicts with a State's need for the radioactive source versus the State's capacity to effectively manage the source during and at the end of its life cycle. In many cases, the need for the source outweighs the lack of regulatory control and the source may be authorized for export under exceptional circumstances provided that a determination has been made that the source will be managed in a safe and secure manner. For States that lack end-of-life management capacity, the establishment of regional radioactive source repositories could assist in this regard.

9.3. Timelines

The CNSC seeks import consent from the importing State authority for the export of all Category 1 radioactive sources from Canada, regardless of the importing State's commitment to the Code and the Guidance. For States that have made a commitment to the Code and the Guidance, it is an expectation of the CNSC that a response to the request will be provided by the importing State authority within the specified timelines. Adherence to timelines is important in order to not delay legitimate transfers of radioactive sources. To this effect, the CNSC has established a service standard for the processing of applications for export licences of three weeks.

9.4. Point of contact

If an importing State has not provided the IAEA with a point of contact, or the importing State has not adequately maintained point of contact information, identifying an appropriate regulatory authority in the importing State can cause delays in authorizing export transactions. The CNSC encourages the point of contact to add or revise their details on the IAEA's list of national contact points. The point of contact should also be aware of their roles and responsibilities associated with the designation.

9.5. Import consent

The use of bilateral arrangements has improved the import consent process and since the 2010 IAEA Code of Conduct Review Meeting, the CNSC has seen a very modest increase in the number of import consent requests from exporting States for the import of Category 1 radioactive sources into Canada. This increase is a result in part of broader communication with counterparts in other exporting States, IAEA regional workshops on implementation of the Code and the Guidance, established arrangements between the CNSC and foreign regulators and also from increases in State's commitments to the Code and the Guidance. However, there still remains an ongoing issue with States that have made a political commitment to the Code and the Guidance and who fail to respond to import consent requests or who fail to request import consent for the export of Category 1 radioactive sources to Canada.

9.6. Assessment of the State regulatory framework

In accordance with the Code and the Guidance and also to ensure that Canada meets its international commitments, the CNSC reviews the importing State regulatory framework as part of its export application assessment. The CNSC relies on information provided by the importing State, open source information, the Guidance Questionnaire responses and various other methods.

One of the main changes to the 2012 Guidance was the revised Questionnaire. The purpose of this revision was to provide a tool for both the importing and exporting States to efficiently obtain information on a States capacity to effectively manage radioactive sources. Exporting States should consider requesting responses to the Guidance Questionnaire from the importing State authority.

9.7. Confirmation of receipt of imported sources

No provision exists under the Code and the Guidance for the importing State authority to confirm receipt of the radioactive source by the intended end user to the exporting State authority. On occasion, the CNSC has requested information and has also provided information related to the receipt of radioactive sources. Although no instances of loss or diversion of Canadian origin radioactive sources have been identified, establishment of a procedure to confirm receipt of exported radioactive sources would further enhance the safety and security of such sources by providing assurances that the intended end user is in receipt of the exported source. To address the lack of a confirmation of receipt provision in the Guidance, the CNSC has begun including a confirmation of receipt provision in several current bilateral administrative arrangements.

9.8. Prior shipment notifications

All export licences issued by the CNSC for the export of Category 1 and 2 radioactive sources contain a licence condition making it a requirement for the licensee to issue prior shipment notifications to the importing State authority and to the CNSC. Conversely, it is the expectation of the CNSC that States committed to the Code and the Guidance will submit prior shipment notifications for Category 1 and 2 radioactive sources being exported to Canada. Category 1 and 2 radioactive sources are often received in Canada without prior shipment notification. Not consistently receiving prior shipment notifications for the import of radioactive sources into Canada remains an issue of concern for the CNSC. This issue is further compounded when the CNSC is not provided the opportunity to grant import consent for the import of Category 1 radioactive sources into Canada.

9.9. Post-shipment verifications

All export licences issued by the CNSC for the export of Category 1 and 2 radioactive sources contain a licence condition making it a requirement for the licensee to issue a post-shipment verification to the CNSC. The post-shipment verification serves as a final verification that the radioactive source has been exported from Canada.

10. CONCLUSIONS

Despite the challenges faced by many States in fully implementing the Code and the Guidance, the CNSC is encouraged with the level of political commitment to them. More work however is required to assist and encourage States in achieving implementation of their commitments in order to achieve a global, harmonized regime to ensure the safety and security of radioactive sources.

In closing, Canada strongly encourages those States that have not yet committed to the Code and the Guidance to do so and strongly encourages full implementation of their provisions.

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SECURITY OF RADIOACTIVE SOURCES FRANCE–IAEA COOPERATION
France repatriation policy

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Abstract

Some very high activity sealed radioactive sources remain dangerous a long time after they become disused. For both safety and security objectives, it is essential to find reliable solutions for their management. Following the first Nuclear Security Summit in Washington, where a political commitment was taken at the highest level, France and the IAEA finalized in 2011 a support plan aimed at facilitating the safe and secure management of the most vulnerable disused sources of French origin. This support plan was put in place in the framework of a wider bilateral practical arrangement on nuclear security. The paper presents the scope, objectives and implementation of the support plan, and introduces discussion material on possible ways to improve the management of disused sealed radioactive sources worldwide.

1. INTRODUCTION

Some very high activity sealed radioactive sources (SRSs) remain dangerous a long time after they become disused. For both safety and security objectives, it is essential to find reliable solutions for their management.

Following the first Nuclear Security Summit in Washington (2010), where a political commitment was taken at the highest level, France and the IAEA finalized in 2011 a support plan aimed at facilitating the safe and secure management of the most vulnerable disused sources of French origin. This support plan has been preceded by a cooperation between France and the IAEA for two specific operations:

- In 2003, a LISA3 device was repatriated from Côte d'Ivoire to France. This operation was prepared by the French Alternative Energies and Atomic Energy Commission (CEA, Commissariat à l'énergie atomique et aux énergies alternatives) and the IAEA, and needed contributions from the Ministry of Foreign Affairs, the CEA, the Institute for Radiological Protection and Nuclear Safety (IRSN, Institut de radioprotection et de sûreté nucléaire), AREVA/TNI and CIS bio international. The global activity was some 700 TBq ^{137}Cs.
- In 2006 and 2008, French experts contributed to IAEA investigations concerning disused radioactive sources in Madagascar and identification of French origin sources or devices.

This support plan was put in place in the framework of a wider bilateral practical arrangement on nuclear security. This paper presents the scope, objectives and implementation of the support plan, and introduces discussion material on possible ways to improve the management of disused sealed radioactive sources (DSRSs) worldwide.

2. FRANCE–IAEA SUPPORT PLAN

2.1. Scope, objective and activities of the support plan

2.1.1. Scope

Priority will be given to those DSRSs of French origin which belong to Category 1 and 2 (see IAEA Safety Standards Series No. RS-G-1.9, Categorization of Radioactive Sources [1]) and are not secured in accordance with the recommendations set out in the guide IAEA Nuclear Security Series No. 11, Security of Radioactive Sources [2]. On a case by case basis, radioactive sources of lower categories and other origins or devices manufactured in France but containing a radioactive source of uncertain origin, or several radioactive sources among which only a fraction is of French origin, may also be considered, subject to a decision by the French regulatory authorities.

2.1.2. Objective

The objective of technical support regarding the safe and secure management of DSRSs of French origin is to improve the safety and security of DSRSs which have the potential to cause serious radiological consequences if they are involved in accidents or malicious acts, by developing/identifying activities designed:

- To collect and collate available information about relevant DSRSs of French origin and their locations, including through active search operations for sources out of regulatory control;
- To verify and complete the collected information;
- To determine what, if any, actions need to be taken to ensure the safety and security of the sources;
- To determine where French expertise (including equipment, tools and facilities) can be used in the source recovery or in safe and secure storage operations;
- To ensure the safety and security of sources, including safe and secure storage or source recovery, source repatriation and appropriate management in France.

2.1.3. Activities

Potential activities under this support plan to improve the security of radioactive sources and, in particular, the safe and secure management of DSRSs of French origin include:

- Planning (prioritization of recipient countries based on proposals from the parties to the practical arrangement);
- Preparation for activities in a particular country (collection and evaluation of available information, decision on necessary missions and team composition, contacting and agreement with the recipients' State authorities);
- Fact finding missions;
- Evaluation of fact finding missions results and decision on follow-up activities;
- Field operations to provide safe and secure management and, as appropriate, recovery of the DSRSs;
- Follow-up on mission(s), if necessary.

2.2. Implementation of the support plan: 2011–2014 operations

Several actions have been carried out since the support plan's finalization:

- In 2011, a radiotherapy Alcyon device was repatriated from Madagascar; this operation was carried out by CIS bio international. The activity was some 20 TBq ^{60}Co.
- In 2011 and 2012, the CEA and CIS bio international established a diagnosis of the inventory of Category 1 and 2 SRSs exported from France, and developed a prioritization method taking into account A/D values, device characteristics and the security environment of the source (if known).
- DSRSs are considered a priority issue for the implementation of the support plan: interim storage in the user's premises is acceptable only for a very short time.
- In 2012, French experts contributed to two fact finding missions organized by the IAEA.
- Other operations are under preparation in five countries, and realization is planned in 2013–2014.

2.3. Capacities and conditions for the implementation of the support plan

2.3.1. Information on sources

Category 1 and 2 sources produced in France were manufactured by the CEA and CIS bio international. Both organizations stopped production and supply of SRSs. Since 2009, the CEA and CISBIO have been cooperating within the framework of GIP sources HA for the management of high activity DSRSs.

In 2012, a file of exported high activity sources or devices has been elaborated. This file is updated and improved whenever precise information is obtained from IAEA fact finding missions, from users of other countries, or from other source producers or suppliers (who may have re-sourced and/or moved or removed some devices). According to this file and to our knowledge, some 300 Category 1 and 2 sources are still used or stored:

- Some 1800 are ^{60}Co sources, including 533 in Alcyon/Cirus radiotherapy heads;
- Some 1200 are ^{137}Cs sources, including 769 in IBL437 blood irradiators.

2.3.2. Information and know-how on devices

Gathering information and know-how on devices is a key issue, because as far as Category 1 and 2 sources are concerned, inadequate operation on a device including such sources could be dangerous. On the other hand, open information on procedures and tools for the safe extraction of DSRSs from devices would increase the security risks.

CIS bio international has a good knowledge on many types of devices that were designed by CISBIO (IBL 137/437/637; SV68, ICO 4000/20 000) or maintained and re-sourced by CISBIO (Alcyon/CIRUS and other radiotherapy heads).

In the case of companies that no longer exist, such as Conservatome, GAAA or Massiot-Philips, some documentation can be found in the IRSN records on devices or transport authorizations.

In coherence with the planning of DSRS management in France, GIP sources HA has been created for a maximum duration of ten years, which leads to an end by 2018.

The CEA and IRSN are preparing a cooperation framework, with the main objective of providing knowledge and documentation on ancient devices from IRSN to GIP sources HA for the implementation of the support plan.

2.3.3. DSRS transport capacities

International transport of such sources requires the availability of Type B(U) containers and a cooperation with forwarding and transport companies with adequate expertise and authorizations. Table 1 gives an overview of the main characteristics of some Type B(U) containers that are used or planned to be used for ^{60}Co and ^{137}Cs DSRS management.

As a result of a case by case analysis, preference is given to the lightest solution because the cost and feasibility of international transport are strongly related to the shipping weight.

TABLE 1. MAIN CHARACTERISTICS OF TYPE B(U) CONTAINERS USED FOR DSRS TRANSPORTS

Container	CC33	PO-02	PO-09	MANON	UKT10	TN-MTR
Operator	CISBIO	GSR	GSR	CISBIO	GSR	AREVA/TNi
Shipping weight (kg)	3 000	3 300	4 600	12 000	12 300	23 400
Max. load (kg)	2 000	2 000	3 000	4 000	6 000	2 800
Typical device	Alcyon head IBL437	IBL137	IBL637	RTGs	SV68	ICO4000

2.3.4. Import authorizations

For the implementation of the support plan, an import authorization in France was necessary: CISBIO asked and obtained from the French Nuclear Safety Authority (Autorité de sûreté nucléaire) an authorization for the import of SRSs and devices including sources in the following cases:

— Import of sealed sources and devices previously supplied by CISBIO and the CEA;
— Import of devices supplied by French companies now closed down, in the framework of France–IAEA support plan.

2.3.5. DSRS management capacity when repatriated to France

Besides transport, the key needs for the management of Category 1 and 2 DSRSs are the availability of a hot cell and of interim storage capacities. A specific nuclear facility (INB 29) in Saclay, operated by CISBIO, has a hot cell with a capacity of up to 11 000 TBq of ^{60}Co or ^{137}Cs, and an interim storage with a capacity of up to 55 000 TBq of ^{60}Co and up to 18 000 TBq of ^{137}Cs.

Although interim storage is a necessary step, it is not a final solution. For this reason, GIP sources HA has developed a strategy for the management of all high activity ^{60}Co and ^{137}Cs sources.

Some batches of sources are exported for recycling by producing companies. Sources that cannot be recycled will be conditioned in waste packages as radioactive waste.

— Cobalt-60 packages will be stored for some five years and sent to surface disposal operated by the National Radioactive Waste Management Agency (Andra, Agence nationale pour la gestion des déchets radioactifs).
— Caesium-137 packages will be stored for some 10 to 40 years and should be sent to the geological disposal site planned by Andra (depending on the conclusions of the public debate in process).

As soon as the final disposal waste package specifications are known, the conditioning of DSRSs in waste packages, followed by waste package storage, is considered to improve safety and security in comparison to the mere storage of DSRSs or devices including DSRSs.

2.3.6. Interim storage and disposal in the State using the sources

In the framework of the support plan, IRSN can provide expertise on safe and secure management of DSRSs, and Andra can provide solutions for the disposal of some categories of DSRS as well as other radioactive wastes.

2.3.7. Financing

Repatriation of a device including one or several very high activity DSRSs is a costly operation and financing is a real issue. The typical cost is in the range of €150 000–250 000, depending on the device and the State (transport costs may vary significantly from one State to another).

For a first batch of operations, a sharing of the funding was agreed: the IAEA will finance repatriation, using EU voluntary contributions to the IAEA Nuclear Security Fund, and France will take care of the costs of the future management of DSRSs and devices after repatriation.

Nevertheless, funding by the country of origin should remain an exception: the responsibility for safety and security of SRS and DSRSs belongs to the State (and inside the State to the licensee), where the sources are used or have been used.

3. IMPROVING DSRS MANAGEMENT: MATERIAL FOR DISCUSSION

The following proposals present the authors’ personal views and do not reflect an official position from the CEA or France.

(a) The first priority in order to improve safety and security of DSRSs should be to avoid their storage on the site where they were used.

(b) The most efficient way to achieve this objective would be to develop good commercial practices. Any delivery of a new radioactive source, a new device including one or new technology replacing one should be strictly linked to the recovery of replaced DSRSs or devices. This requires a 'new' interpretation of the 'return to supplier' practice.

(c) When immediate return to supplier is not possible, management of DSRSs should be organized by user countries on a national level in safe and secure interim storage facilities.

(d) In addition to interim storage, a national strategy is necessary:
   (i) For some short period DSRSs, long term interim storage can be a solution, and medium term interim storage can make transport easier (if the conditions for transport in Type A packages are met, after radioactive decay).
   (ii) For many DSRSs, low cost disposal such as the borehole concept proposed by the IAEA, as well as surface or subsurface disposal can be a solution.

(e) For some very high activity sources such as Category 1 or 2 ^{137}Cs sources, geological disposal will finally be necessary.

(f) For user countries without a nuclear power programme, this leads to the conclusion that some repatriation programmes will be necessary for at least a small number of Category 1 and 2 DSRSs.

(g) States that plan for such a repatriation programme should inform the IAEA and the country of origin, and prepare funding during the interim storage period.

(h) An international funding instrument on the IAEA level would help funding issues: €200 000 represents a very large budget and paying €10 000–20 000 per year to a specific fund during 10 or 20 years might make things much easier.

(i) Efforts should be made to reduce transport costs:
   (i) Producing States should avoid the loss of special form agreement of radioactive sources or DSRSs, unless there is a real safety issue.
   (ii) Transport casks used for the delivery of radioactive sources or devices should be as far as possible maintained as long as some of the delivered radioactive sources or devices are still in use.
   (iii) Transport casks are often authorized for one specific type of radioactive source or device. The IAEA and national authorities should encourage the development of more generic authorizations to an as large as possible variety of similar radioactive sources and devices.

(j) For the implementation of repatriation programmes the ‘return to country of origin’ concept should be understood with in a flexible way. The country of origin could be the supplier or the producer of the device or the source or the radioactive material used to produce the source and in addition, a legal solutions should be found for sources of unknown origin.

4. CONCLUSIONS

The support plan between France and the IAEA opens the way for safe storage or repatriation of French origin disused radioactive sources or devices. Nevertheless, the first responsibility rests with the State where the sources are or were used: knowledge on used and disused high activity sources and devices, national strategy, planning and financing issues.

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REPATRIATION OF GAMMA CHAMBERS EXPORTED BY INDIA

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Abstract

The Board of Radiation and Isotope Technology (BRIT) is engaged in the production and supply of laboratory gamma chambers. The gamma chambers are self-shielded devices in which a number of ^{60}Co source pencils placed in a cylindrical cage. The gamma chambers are type approved as a device and a transportation package separately by the Atomic Energy Regulatory Board. BRIT has exported number of such gamma chambers. For some of the gamma chambers, the type approval validity period is over and can no longer be transported. Hence, the radiation sources need to be transferred to a type approved package before transportation. BRIT has decommissioned five such gamma chambers so far and sources have been repatriated back to India.

1. INTRODUCTION

The Board of Radiation and Isotope Technology (BRIT), a unit of the Department of Atomic Energy, India, is engaged in production and supply of laboratory gamma chambers, also known as gamma cells. These gamma chambers are used for number of research applications and are based on ^{60}Co radiation sealed sources. The gamma chambers are self-shielded devices in which number of ^{60}Co source pencils placed in a cylindrical cage. The cage surrounds a cylindrical sample chamber in which the material to be irradiated is placed. The irradiation takes place when the sample chamber is brought in front of the cage containing the ^{60}Co pencils. The sample chamber is part of an electrically driven drawer assembly which can move up and down as desired. For putting the samples for irradiation, the drawer is moved up fully so that the sample chamber comes out of the shield to enable cover of the sample chamber removed (see Fig. 1). After placement of materials for irradiation, the time needed for irradiation to deliver the desired radiation dose is set on the control system, which then initiates movement of drawer to the irradiation position and

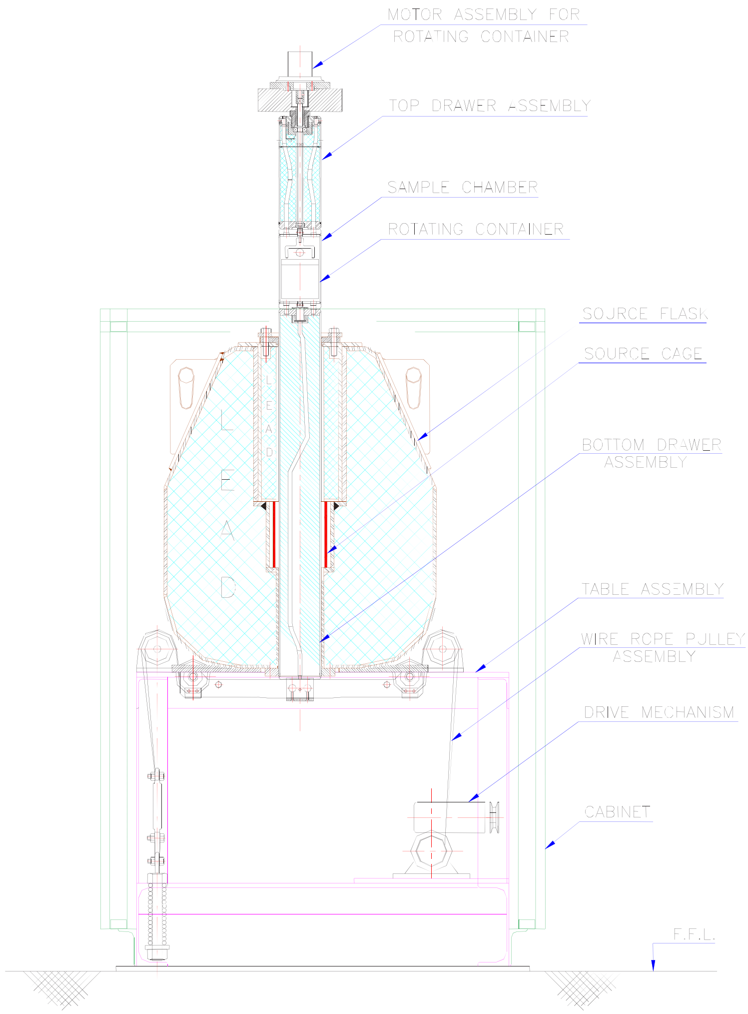

FIG. 1. Sectional view of a typical gamma chamber.

then bring it up after the set irradiation time. BRIT used to make GC-900 in which the sample chamber had a volume of 900 cm^3. Another model, GC-4000A, was introduced which had a sample chamber volume of 4000 cm^3. Both of these models, which use carbon steel as the material of construction, have now been discontinued. BRIT currently makes GC-1200 and GC-5000 models with sample chamber volumes of 1200 cm^3 and 5000 cm^3, respectively. Both of these models use austenitic stainless steel as the material of construction. All the gamma chamber models have an especially designed transportation crate to facilitate the transportation within the country or for export. The gamma chambers are designed keeping in view the requirements as specified in ANSI standards for self-contained irradiators as well as transport packages (see Refs [1–4]). The gamma chambers are approved for transportation by road, sea as well as by air.

2. TYPE APPROVAL OF GAMMA CHAMBERS

The gamma chambers in India are type approved as a device and a transportation package separately by the Atomic Energy Regulatory Board (AERB). The design of these conforms to American National Standard ANSI/HPS N43.7-2007 for Safe Design and Use of Self Contained Dry Storage Gamma Irradiator (Category I) [4]. Stringent requirements of safe transportation of radioactive materials as stipulated in various national and IAEA safety standards are to be met in design of the irradiator. The design needs to meet the Type B(U) requirements for both normal and accidental conditions of transport. The AERB was formed in India in 1983. Before that, the transport of radioactive materials was regulated by the Division of Radiological Protection, Bhabha Atomic Research Centre.

3. GAMMA CHAMBERS IN INDIA

In the initial years, India had eight imported gamma cells manufactured by Atomic Energy of Canada Limited (six GC-220 and two GC-200). Four of these are still in use. BRIT has already decommissioned three such gamma cells. One was scrapped, of which all the sources were subsequently recovered in an involved campaign.

So far, 184 BRIT manufactured gamma chambers have been supplied to different institutions in India and abroad. For all domestic institutions, the commissioning and decommissioning of gamma chambers is carried out by BRIT, which has already decommissioned 20 gamma chambers supplied within India.

4. EXPORT OF GAMMA CHAMBERS

The first gamma chamber, a GC-900, was exported to the University of Cluj, Romania, in 1968. So far, 31 gamma chambers have been exported and installed (eleven GC-900, eleven GC-5000 and nine GC-4000A). For the gamma chambers which were exported earlier, there was no agreement for taking back the device or the radiation sources after the end of their useful life. The first export was a GC-900 in 1968. The useful life of many of the gamma chambers is already over.

The gamma chambers which were exported earlier have exhausted their validity period and can no longer be transported. Hence, the radiation sources need to be transferred to a type approved package before transportation.

5. REPATRIATION OF GAMMA CHAMBERS

In conformity with the Code of Conduct on the Safety and Security of Radioactive Sources (Code) [5], BRIT accepts the decayed radiation sources contained in the gamma chambers exported to other countries for disposal. The sealed sources are verified for their origin of supply and their integrity before dispatch and accepted at the BRIT facilities in Mumbai. The possible options for repatriation are:

(a) Transport of the gamma chambers along with the decayed sources:
  — This is not possible due to the non-availability of Type B(U) certification of the flask and the complexities involved in transportation of Type B(M) packages.

(b) Removal of the decayed sources from the gamma chambers and transferring them in a Type B(U) approved flask using a hot cell facility in the host country:
  — A suitable hot cell facility is generally not available in many countries, since most of the gamma chambers are in developing countries.

(c) Use of a mobile hot cell at user’s place if it is possible to arrange.

(d) Special extraction tool:
  — A suitable custom built transfer mechanism for transfer of the decayed source from the gamma chamber to a Type B(U) approved flask, where the decayed source strength of these units becomes very low.

The following describes the repatriation exercises so far carried out by BRIT.

5.1. Myanmar

A GC-900 unit Sr. No. 9, with a ^{60}Co activity of 2553 Ci, was supplied to the Department of Veterinary Research, Government of Myanmar, Yangon, in 1970. In an incident of unrest in 1990s, the control panel and driving unit of the gamma chamber were damaged. However, there was no damage to its shielded housing, and the sealed sources remained fully shielded. The authorities there decided to cover it fully by constructing a brick wall housing around it and closing the top with a slab to be sure that there would be no radiation leakage. A request was received by BRIT to decommission the unit. A BRIT team was assigned to do the job, and the first task was to carefully demolish the housing constructed over it. The unit was decommissioned and packed in the transportation crate meant for it. The unit finally got repatriated in July 2000. It was transported back to BRIT, India, by sea as a Type B(M) package.

5.2. Uruguay

BRIT had exported two gamma chambers to Uruguay. The first one, a GC-4000A Sr. No. 2, with a ^{60}Co activity of 3360 Ci, was supplied to the Faculty of Agronomy, Milan, in 1970. The second one, also a GC-4000A Sr. No. 12, with ^{60}Co activity of 7600 Ci, was supplied and installed under a United Nations Development Programme initiative in Montevideo in 1984.

The IAEA had approached BRIT for repatriation of ^{60}Co radiation sources contained in GC-4000A Sr. No. 2 supplied to Uruguay in 1970. The ^{60}Co activity, which at the time of supply was 3360 Ci had decayed to 16 Ci. The IAEA had arranged to have the 15 sealed source pencils removed by another agency. The sealed sources were encapsulated into a special form capsule. This work was carried out by use of a mobile hot cell. The special form capsule was loaded into a type approved transportation flask and sent to the Southwest Research Institute (SwRI), San Antonio, United States of America, for identification and inspection of the sealed sources by BRIT. The radiation sources were inspected by BRIT team at SwRI and were loaded and sealed in two Type A containers and dispatched to Mumbai. The containers were received by BRIT from SwRI. The sealed sources were removed in a hot cell and the empty containers were returned to SwRI, thus completing the repatriation process of one of the GC-4000A gamma chambers exported to Uruguay.

5.3. Sri Lanka

BRIT has exported the following three gamma chambers to Sri Lanka:

(a) GC-900 Sr. No. 20, with 2036 Ci of ^{60}Co activity, to the Central Agricultural Research Institute, Kandy, in June 1973;
(b) GC-900 Sr. No. 64, with 2125 Ci of ^{60}Co activity, to the Central Agricultural Research Institute, Kandy, in June 1986;
(c) GC-5000 Sr. No. 16, with 13 640 Ci of ^{60}Co activity, to the Atomic Energy Authority, Colombo, in April 2003.

In 2012, BRIT decommissioned the three above mentioned gamma chambers, which were exported.

In the GC-5000 unit, there were mechanical problems in the movement of drawer assembly. The drawer was stuck along with the sample chamber in the irradiation position. Since it had Type B(U) approval, it was packed into its transportation crate after rework on the drawer assembly (see Fig. 2).

Both of the GC-900 units had completed their useful life. At the Central Agricultural Research Institute, Kandy, where these units were installed, there was no availability of hot cell for exchange of ^{60}Co sources. A special purpose source extraction tool was developed which could extract all the sealed sources together which are contained in a source cage (see Fig. 3).

The extraction tool enables easy removal and placement of the source cage along with decayed source pencils in a Type B(U) approved flask while keeping the exposure as low as possible during the operation. It can handle up to 50 Ci of ^{60}Co to keep radiation field within 10 µSv/h at a distance of 3 m. So the exponent to personnel is a minimum. The entire operation has to be done from a safe distance of about 2–3 m. The tool was designed to suit the lead plug cavity of GC-900. The tool consists of a shielding housing and a gripper to engage the source cage inside the cavity of the flask. The gripper consists of four spring loaded fingers which protrude out on the downward movement of inside plunger to engage the cage. A mechanically driven signal is available to confirm the attachment of source cage on to the gripper and having it withdrawn into the shielded housing. A spring loaded lock automatically locks the lifting assembly of gripping tool at precise location. Once the gripping device holds source cage along with the source pencils, an electromagnetically operated closure disc is attached at the bottom side to avoid any radiation field around. The GC-900 unit has a source cage with 24 source holders to accommodate source pencils. The tool along with the source cage and all the sealed sources inside can be taken on top of the transportation flask in which the final repatriation is to be done after removing its top plug to facilitate loading of source cage (see Fig. 3). The dimensions of the source extraction tool are designed to suit the transportation flask BLC-100. The tool can handle 50 Ci of ^{60}Co activity when the radiation field is to be limited to 10 µSv/h at 3 m distance.

The two GC-900 units had a residual ^{60}Co activity of 9.5 Ci and 78 Ci. The source extraction tool was successfully deployed in October 2012 in Kandy, Sri Lanka, to transfer the source cage from GC-900 unit Sr. No. 20 with 9.5 Ci ^{60}Co into the transportation flask BLC-100 with Type B(U) approval to bring it back to BRIT, India. The total man-rem expenditure in this entire exercise was 264 µSv.

The other GC-900 unit had residual ^{60}Co activity of 78 Ci and had a valid Type B(M) approval. It was packed in its transportation crate to enable its repatriation (see Fig. 4).

FIG. 2. GC-5000 being put into its transportation crate.

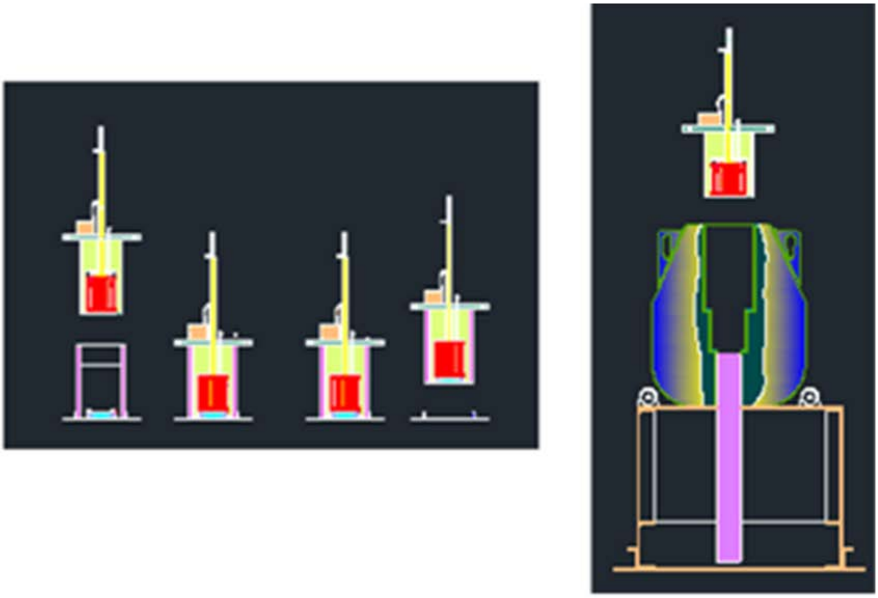

FIG. 3. Source extraction tool.

FIG. 4. Source extraction tool in use in Kandy, Sri Lanka.

6. CONCLUDING REMARKS

BRIT has been involved in production of gamma chambers for number of decades. Due to the advent of new regulations, many of the exported units do not have valid Type B(U) certifications. In spite of this, BRIT has followed the Code in true spirit and has repatriated five old gamma chambers which were exported a long time ago. For all of the repatriated gamma chambers, there was no agreement to take the decayed sealed radiation sources back.

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IAEA-CN-204/156

BELGIAN GLOBAL APPROACH ON THE RADIOLOGICAL SURVEILLANCE OF RADIOACTIVE ORPHAN SOURCES AND RADIOACTIVE SUBSTANCES IN SCRAP METAL AND NON-RADIOACTIVE WASTE

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Abstract

In order to enhance the control of radioactive sources, the Belgian Federal Agency for Nuclear Control has created a global approach on the radiological surveillance of radioactive orphan sources and radioactive substances in scrap metal and non-radioactive waste. As one of the European leaders, Belgium has had since late 2011 a strong legal basis to organize the effective monitoring of possible presence of radioactive material in conventional waste.

An important aspect includes the financial solution related to the orphan source problem. Again, a legal basis and a workable system have been put in place. The financial solution resulted from the concern that the protection of the population and the environment should not depend on the liability of the finder of an orphan source. The monitoring results of 2012 are illustrated in detail, and the mandatory reporting of alarms are analysed by sector, origin, type of material and seriousness. The figures, statistics and conclusions that can be drawn are discussed extensively. Finally, the challenges and difficulties of this system are discussed. Past and future challenges receive the necessary attention.

1. INTRODUCTION

In recent years, maintaining the control over radioactive sources has undoubtedly been a subject that is gaining in importance globally. After several accidents — for example, Algeciras (Spain), Bangkok (Thailand), Goiânia (Brazil), Istanbul (Turkey) and Juarez (Mexico) — the Belgian Government elaborated a global approach on the radiological surveillance of radioactive orphan sources and radioactive substances. Firstly, it must be avoided at all cost that a radioactive source appears in an uncontrolled circuit. Therefore, a strict system for the use of radioactive sources based on licences, periodical controls and inspection was set up.

Additionally, it is also important to have the possibility to detect uncontrolled sources and to react appropriately when an orphan source is found. At the same time, the feasibility and economic impact of the measurements should be considered. In 2006, a specific guideline [1] and technical annex [2] were published in the Belgian legislation for establishments equipped with a portal monitor in operation.

However, there was no legal ground to impose the installation of a portal monitoring system. On 13 September 2011, the Federal Agency of Nuclear Control (FANC) was confronted with a serious incident: the contamination of an industrial blast furnace at La-Louvière (BE). This incident caused enormous financial damage to the company and poses, now and in the future, enormous challenges in terms of technical and organizational solutions.

At the end of 2011, an official legal base in the form of a Royal Decree [3] was published in which the obligations for the different establishments are described together with a corresponding guideline [4]. The follow-up, the announcement and the practical elaboration of the Royal Decree and guideline were coordinated by the FANC.

The principles of this legal base will be explained further, as well as the challenges for the future. The results achieved in 2012 will also be discussed. To ensure a workable, feasible and high quality follow-up, the FANC is facing numerous challenges.

2. BELGIAN GLOBAL APPROACH

The Belgian approach developed by the FANC and its partners includes several aspects.

2.1. Preventing radioactive sources from ending up in non-nuclear sector

Beyond the control of ionizing radiation that already exists in Belgium (see the Royal Decree of 20 July 2001 laying down the General Regulations on the Protection of the Public, the Workers and the Environment against the Hazards of Ionising Radiation (GRPIR), the FANC has strengthened the professional and regulatory monitoring of high activity sealed sources in order to prevent any disappearance or misuse of high risk orphan sources and to avoid its outbreak. Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources [5] was transposed into Belgian legislation on 23 May 2006. As a result, it is now necessary to provide individual records of each high active sealed source containing information about the unique identification, marking and specific testing, among other things. Moreover, targeted inspections and complementary technical controls have also been made compulsory. A record sheet is now provided for each orphan source.

2.2. Defining orphan source sensitive flows

In cooperation with the stakeholders and the environmental administrations of the three Belgian Regions, and relying on the national and international experience that it has acquired, the FANC has identified which flows run a risk of containing orphan sources among material flows treated by the waste recycling and processing industries. These flows are identified in accordance with the waste classification codes set up by the European Commission and are declared orphan source sensitive flows. The complete list of codes is listed in appendix 1 of the Royal Decree of 14 October 2011.

2.3. Identifying the orphan source sensitive facilities

Non-nuclear industrial sites processing one or several of those supply flows with a risk of containing orphan sources are de facto listed as orphan source sensitive facilities (OSSFs). All these facilities have to meet a minimum of requirements regarding staff training, vigilance measures and action plan if a source is detected. A procedure needs to be put in place in case a radioactive source is detected.

2.4. Imposing appropriate monitoring in non-nuclear facilities

Among the OSSFs, some have a higher probability of being confronted with an orphan source than others. Consequently, those facilities have to comply with the obligation of screening systematically and automatically every incoming orphan source sensitive flow — in particular by installing a portal monitor.

The complete list of facilities for which a compulsory radioactivity monitoring is necessary, is published in appendix 2 of the Royal Decree of 14 October 2011 (see Table 1 for a summary). This list has been established with the stakeholders and the environmental administrations of the three Belgian Regions. To this end, a careful study of the scrap and waste flows has been carried out in order to identify the nodal points in the scrap recycling network where a monitoring system would be the most appropriate choice. The goal is to keep a balance between the need to monitor as many scrap metal flows as possible without imposing heavy regulations and heavy financial investment costs on small facilities. For example, in this optimization approach, Belgium is considering a threshold limit value of 25 000 t/a of scrap metal entering a facility for imposing the use of an automatic screening system for radioactive materials.

TABLE 1. FACILITIES WITH ACTIVE MONITORING

Types of facilities
Incineration and co-incineration plants
Dumping sites
Facilities for the mechanical handling of scrap with an annual intake of more than 25 000 t of scrap
Facilities for the smelting of ferrous metals and waste materials containing iron with an annual intake of more than 25 000 t of waste materials containing ferrous metal
Facilities for the production and smelting of non-ferrous metals, including alloys and waste materials containing non-ferrous metals, with an annual intake of more than 25 000 t of waste material containing non-ferrous metals
Plants for the mechanical–biological treatment of household waste matter and comparable waste material

The FANC considered that the radiological protection aspect and the achievement of uniform practices should be guaranteed. Therefore, the directive of 3 November 2011 [4] for the follow-up of detections or discoveries of an orphan source in OSSFs was published.

The OSSFs which do not have to comply with the compulsory systematic and automatic screening through radiation portal monitor have to meet a minimum of requirements regarding staff training, vigilance measures and an action plan in case a radioactive source is detected.

On the other hand, the OSSFs which have to comply with automatic screening through radiation portal monitors have to follow the procedure as described in the directive when a portal monitor alarm is triggered. It describes the radiological protection measures to be taken by the staff as well as the information to be provided by the operator to the FANC.

The operator is only allowed to intervene without the assistance of a radiation expert when the radioactivity does not exceed specific levels. Beyond certain levels, an expert in radiological protection needs to be present during the recovery of the source from the shipment. For shipments with naturally occurring radioactive material (NORM), where the radioactivity is generally homogeneously spread over the whole shipment, an additional action level is defined (about twice the natural background) below which no intervention is necessary. The definition of these action levels considerably simplifies the management of radiation related alarms by the operators. This directive has been written in collaboration with the various stakeholders.

2.5. Financing orphan sources

With the gradual introduction of portal monitors, the different industrial sectors became increasingly reticent regarding the financial responsibility for waste treatment associated with radioactive materials and sources discovered in their installations. In the past, when a radioactive source was found and its owner could not be identified, the characterization, management and treatment costs for this radioactive material called ‘orphan source’ had to be paid by the finder.

In order not to compromise the already achieved success, but, instead, to stimulate the further introduction of such portal monitors, the FANC and the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS, Organisme national des déchets radioactifs et des matières fissiles enrichies/Nationale instelling voor radioiactief afval en verrijkte splijtstoffen) became aware that it was necessary to develop a structural mechanism that was able to cover all the costs associated with the management of these radioactive by-products once they had been declared orphan sources.

In March 2007, the Belgian Council of Ministers adopted a financial solution for the costs associated with the waste management of recovered orphan sources, within the framework of the transposition of Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources [5]. This financial solution resulted from the concern that the protection of the population and the environment should not depend on the liability of the finder of an orphan source. When a radioactive source is found, the ‘the polluter pays’ principle is now applied by the FANC, which first tries to identify the polluter and then brings proceedings against him. If the polluter cannot be identified or if the efforts made to identify him are out of proportion with the cost involved, the source is considered as an orphan source and the financial costs are borne by ONDRAF/NIRAS’s Insolvability Fund.

The scope of the intended financial arrangement was not easy to determine. It depended on the definition given to an orphan source and on the degree in which a person, for example the previous holder of the source, could still be held financially responsible for its management and for the damage that might have resulted from its mismanagement. The main objectives of the financial arrangement can be summarized as follows:

- — Preventing the indiscriminate dumping of orphan sources;
- — Promoting the recuperation of discovered orphan sources;
- — Compelling the involved industrial sectors to take their responsibilities;
- — Fairness towards the finders of orphan sources;
- — Being fraud-proof;
- — Introducing a minimum of new administrative burdens.

The costs associated with the management of the orphan source will be borne by a public fund set up by ONDRAF/NIRAS. Originally, this fund aimed at protecting ONDRAF/NIRAS against the risk of insolvency of a radioactive waste producer. However, some restrictions have been introduced and a number of categories of orphan sources are not covered by this mechanism, such as:

- — Sources that do not fit the definition of orphan source are at the expense of the finder;
- — Orphan sources from identifiable practices, work activities involving NORM and technologically enhanced naturally occurring radioactive material and interventions are at the expense of the identified operator;
- — Orphan sources forming an integral part of immovable property are at the expense of the owner of that property (e.g. radioactive lightning rods);
- — Radioactive sources and materials found in contractual supplies originating from foreign suppliers will not be compensated.

In October 2007, the FANC, ONDRAF/NIRAS and most of the professional federations of metal works, waste treatment and recycling sectors signed this protocol regarding the tracking and management of radioactive materials and objects outside the nuclear sector. Operators from OSSFs who wish to take advantage of the financial arrangements for orphan sources need to contact the FANC and register their facilities. They are compelled to take measures to prevent orphan sources from ending up on their sites, in their installations or in the supply of goods and bulk materials. Should such a source be detected, the operator has to follow the guidelines of the FANC and accept its investigation to verify whether its guidelines are complied with and to determine possible responsibilities in order to enhance the identification of the party legally responsible for the presence of the source.

3. MONITORING RESULTS

3.1. Collecting information and providing feedback

The FANC is in charge of registering radiation portal monitors and OSSFs. Each detected radioactive source and each triggered portal monitor alarm needs to be reported to the FANC.

The actions taken by each party (portal monitor operators, hauliers, FANC inspectors and radiation experts, among others) and the characterization information for each source are recorded in a database in order to provide further feedback and to make it possible to continuously assess and enhance the Belgian authorities' approach.

3.2. Registrations

On 31 December 2012, there were 524 Belgian firms officially registered as an OSSF. Of these establishments, 429 (82%) are categorized under 'OSSF without a portal monitor'. The other 95 establishments (18%) dispose of one or multiple portal monitors for the active screening of incoming and outgoing orphan source sensitive flows. An overview of OSSFs in Belgium can be found in Table 2.

In total, there are 201 active portal monitors in the Belgian territory. The majority (48%) can be found in the scrap business. Another large part of portal monitors (26%) are installed on strategic import and export locations such as ports or customs. An overview of the distribution of portal monitors over the different sectors can be found Table 3.

3.3. Alarms

A total of 170 alarms were registered by the FANC in 2012. This equates to an average of around 14 alarms per month, or one alarm every two days. These alarms were mainly detected at facilities with a portal monitor (89%), and occurring mostly in incinerators (36%). These are predominantly due to short life medical waste. Another large number of alarms are caused by scrap processing (34%). This mainly concerns contaminated metals (see Fig. 1).

In essence, most alarms (89%) are registered by operators of a portal monitor, which is normal given the routine screening. The chart above shows in which sectors the other alarms are detected.

TABLE 2. ORPHAN SOURCE SENSITIVE FACILITIES REGISTERED AS OF 31 DECEMBER 2012

Type of OSSF	No.	%
Recycling park (NoPM)	387	74
Scrap (PM)	59	11
Scrap (NoPM)	25	5
Country borders (PM)	13	2
Incinerator (PM)	12	2
Sort centres (NoPM)	11	2
Melting ferro- and non-ferro (PM)	8	2
Unknown	3	1
Melting ferro-en non-ferro (NoPM)	3	1
Landfill (PM)	2	0
Mechanical–biological treatment (PM)	1	0
Total	524	100
OSSF without portal monitor (NoPM)	429	82
OSSF with portal monitor (PM)	95	18

It is interesting to note that the number of detection portals at incinerators only amounts to 3% (see Table 3). They are, however, responsible for 36% of the alarms. This is a specific problem of radioactive medical waste, which requires a specific approach. After analysis of the alarms registered at incinerators, we can conclude that 87% of the alarms at incinerators are caused by medical waste (see Fig. 2).

TABLE 3. PORTAL MONITORS REGISTERED AS OF 31 DECEMBER 2012

	No.	%
Scrap (PM)	97	48
Country borders (PM)	52	26
Melting ferro- and non-ferro (PM)	32	16
Incinerator (PM)	7	3
Landfill (PM)	6	3
Unknown	5	2
Hospital (PM)	2	1
Total	201	100

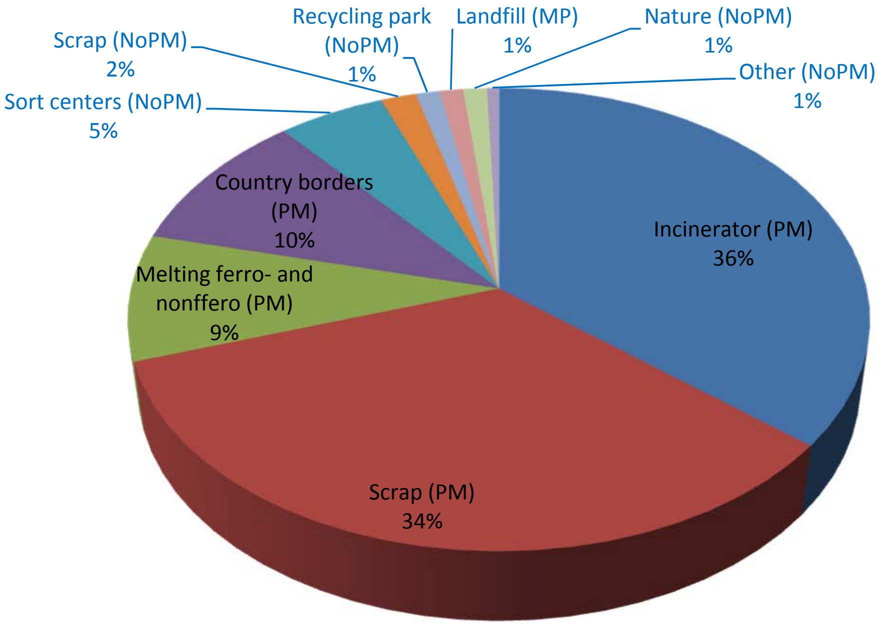

FIG. 1. Alarms register in 2012, per sector.

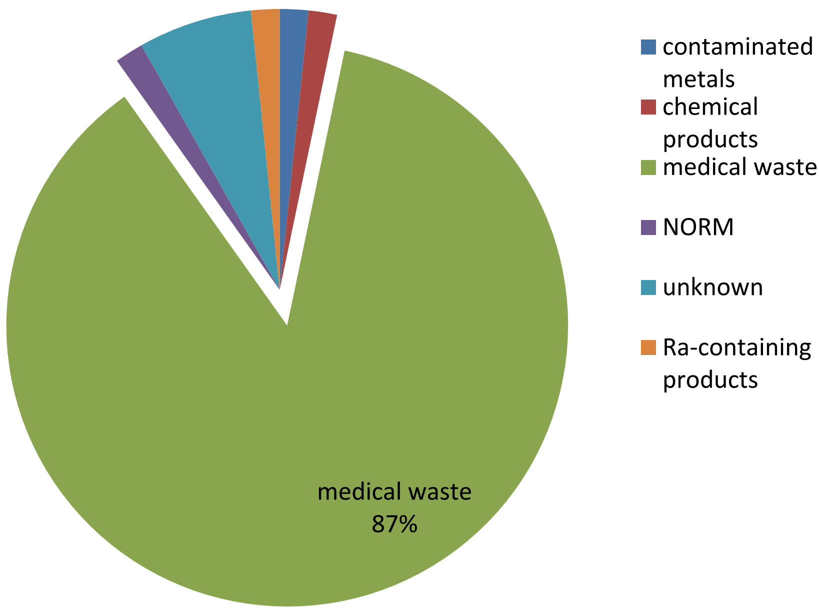

FIG. 2. Type of material at incinerators

3.4. Origins

An overview of the origin of cargoes generating alarms is given in Fig. 3.

Most detected alarms (41%) come from intermediaries, traders such as smaller scrap dealers and sorting centres that do not have a detection portal. In addition, 18% come from foreign cargoes. These are mostly detected at the border (i.e. ports and customs) or in scrap processing operations.

A relatively large number of alarms originate from known medical institutions (e.g. known hospitals). In these cases, the FANC takes action to prevent (still) radioactive medical waste from leaving the premises. An FANC inspector contacts the medical institution and requests an action plan in order to avoid that still radioactive waste leaves the site in the future. If a series of alarms are triggered by a single medical institution, an on-site inspection is conducted by an FANC inspector.

A small part of the alarms (9%) can be attributed to individuals (e.g. delivery of minerals, chemical radioactive products and lightning rods).

Industrial establishments (1%) are facilities that are known to the FANC and have a permit to use radioactive substances under strict conditions and controls. Firms on the other hand are facilities that do not have a permit but still generate alarms (e.g. NORM materials).

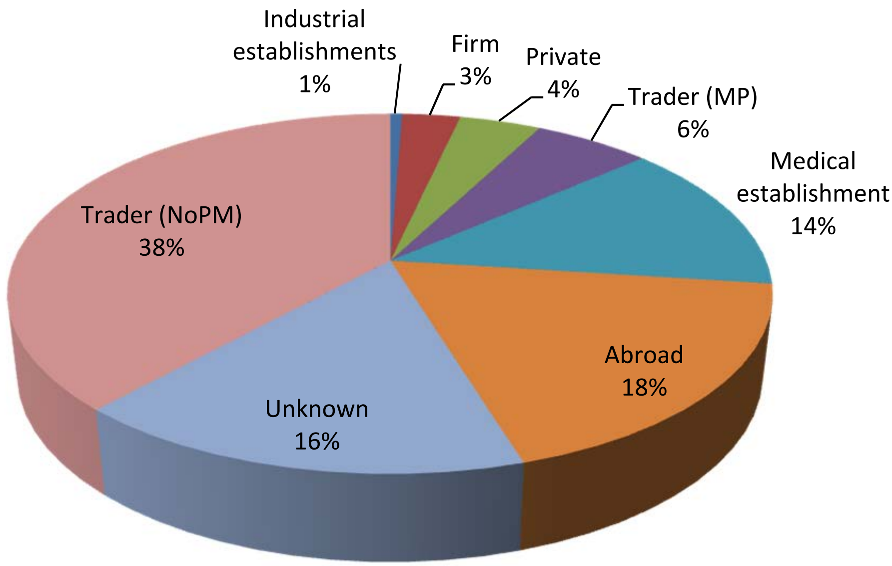

FIG. 3. Origin of cargo.

The FANC is also interested in what comes from abroad (18%) (see Fig. 3). It can clearly be stated that contaminated metals constitute the largest proportion (58%) of this percentage (see Fig. 4). These are metals for which, for example, a radioactive source has been melted during the production process. We also find lightning rods from abroad (7%), as well as NORM material (3%) and products containing radium (3%). Since the origin of the radioactivity is from abroad these cargoes are, in most cases, returned under supervision to the country of origin after contact with the foreign authorities.

3.5. Interventions by expert

If a risk of exceeding certain radiation doses exist, a recognized expert needs to be involved in the further handling of the alarm. These are thus considered as the ‘more dangerous’ alarms. This was the case 17 times in 2012, which corresponds to approximately 10% of the alarms. Obviously, these cases can only occur in facilities where a portal monitor is installed (see Fig. 5).

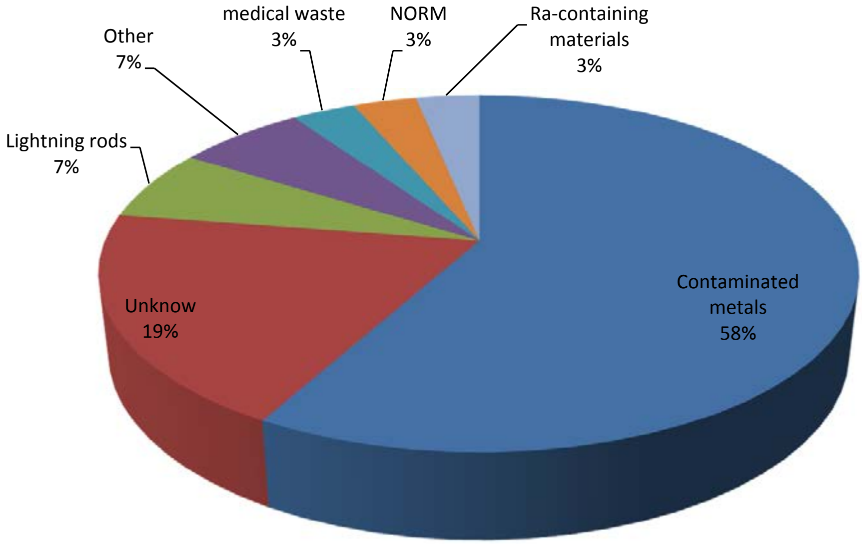

FIG. 4. Types of material from abroad.

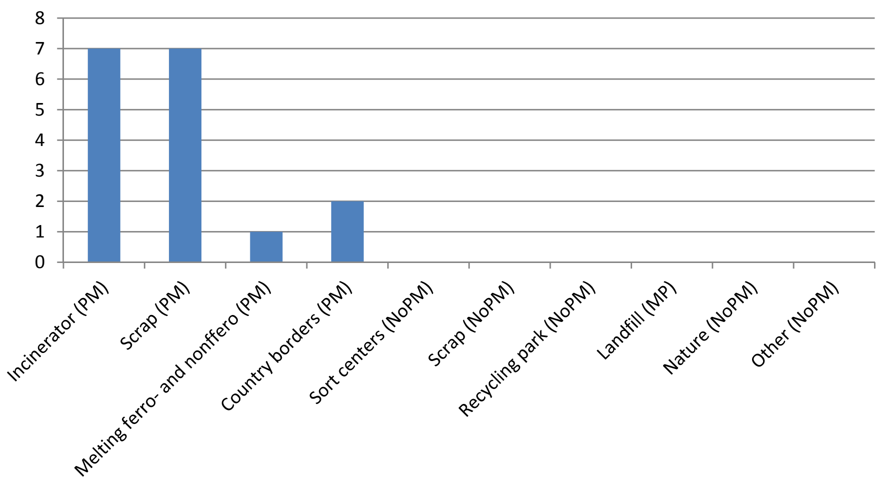

FIG. 5. Interventions by experts.

3.6. Declarations of orphan sources

The FANC decides when a detected source is to be regarded as an orphan source. This generally means that the owner cannot be traced, that the facility has met all the requirements of the FANC and that the guidelines have been followed properly. The costs are then borne by the insolvency fund.

Only 23% of the alarms result in the drawing up of an orphan source certificate for the objects detected (see Fig. 6) as alarms caused by medical waste, foreign waste and NORM waste do not follow the same treatment. The breakdown of those materials mainly regarded as orphan sources can be found in Fig. 7.

4. CHALLENGES

The implementation of the legislation on the field, the uniform approach, preserving radioprotection and preventing any abuse, are key factors in the success of the Belgian approach. These and other aspects create a huge challenge for the future. Therefore, a few subjects that have a huge impact are highlighted. An overview of the different initiatives is briefly discussed but need a continuous follow-up and improvements for the future.

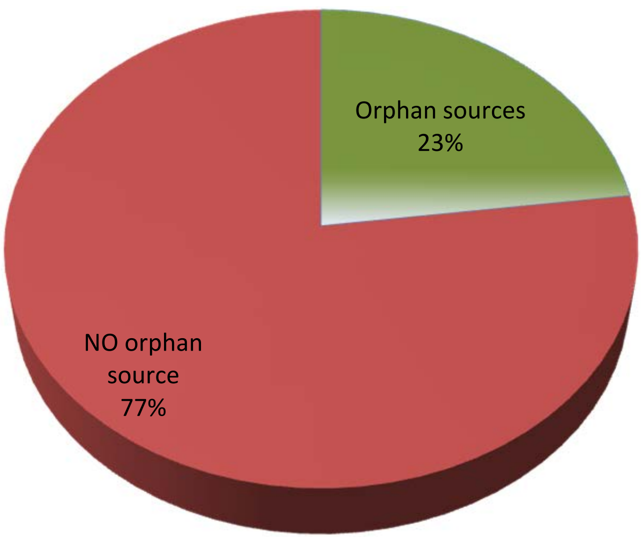

FIG. 6. Orphan sources.

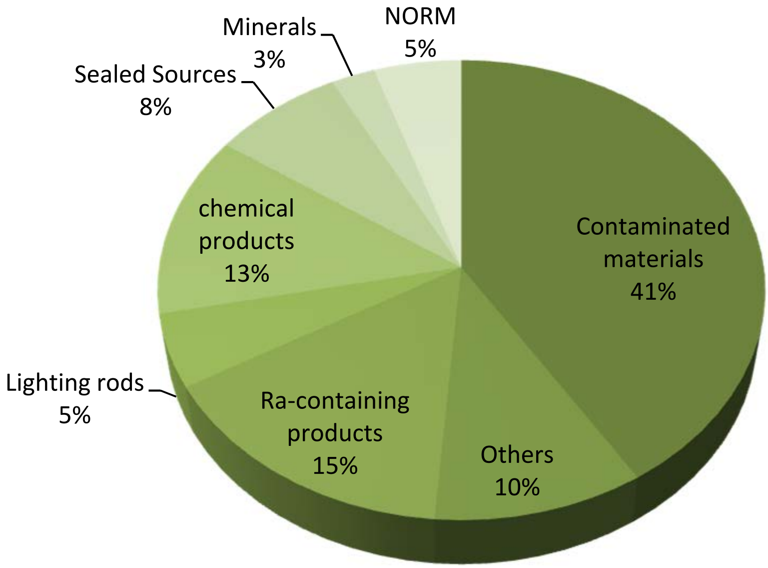

FIG. 7. Types of orphan sources.

4.1. Information

The global approach has been developed in collaboration with most of the professional federations from the metal works, the waste treatment and the recycling sector during several stakeholder meetings. In the future, it is important to inform the different sectors in both an active and a passive way. The FANC uses the following means of communication to inform the stakeholders:

(a) FANC web site[1]: A specific web page with all the necessary information is available.[2] The web site can serve as an information platform for various documents and texts and as a means of distribution to the general public. The following sections can be found on this web page:
- — Introduction: framework of the orphan source problem;
- — Global approach;
- — The regulatory system;
- — Financial solution for orphan sources;

[1] See http://www.fanc.fgov.be.

[2] See http://www.fanc.fgov.be/nl/page/weesbronproblematiek/1203.aspx?LG=2.

- — Training and information: training material from the FANC for the concerned sectors and employees;
- — Frequently asked questions;
- — Monitoring portal wizard: on-line tool that can be used when a portal monitor gives an alarm to determine the various steps and actions in accordance with the guidelines;
- — Experience and feedback;
- — Photo book of radioactive substances that can be found with or without a portal monitor;
- — Posters in digital versions (see below);
- — Press release concerning the publication of the Royal Decree on the tracing of radioactive substances in certain material and waste flows and concerning the management of facilities sensitive to orphan sources;
- — Stakeholders' meeting: the reports and presentations of the meeting are on-line and available for consultation by the stakeholders;
- — Suggestions.

(b) Posters: The FANC has created posters (available in Dutch and French) summarizing the most important messages for the employees on the field. These posters are distributed to all OSSFs. Two versions are available:
- — Poster for the OSSFs without a portal;
- — Poster for the OSSFs with a portal monitor. This poster is slightly different because the main 'hold' points during the intervention are also repeated.

(c) Movie: A movie to explain and visualize the intervention and directives is available. This movie is also used in training courses.

(d) Newsletter: On a regular basis, the FANC informs the different stakeholders by means of a newsletter sent by mail. The newsletter contains several current topics such as international accidents and new initiatives, among other things.

(e) Press releases: Press releases are distributed to highlight the new legislation. The FANC also participates in press conferences to communicate openly to the general public about the orphan source issues.

(f) Official letter to the companies that are involved to inform them about the new legislation and obligations.

4.2. Training

A key factor for the success of the Belgian approach is the education and training of the workers and staff of the involved sectors. This training obligation is published in article 6 of the Royal Decree of 14 October 2011. Therefore, the FANC has taken initiatives to provide all the necessary information and training. The specific needs of the workers and the level of training will always be taken into account. The FANC annually organizes a centralized training day for interveners of orphan source sensitive establishments with a portal monitor. Additionally, the following courses are offered if requested by various establishments or associations:

— Education for the supervisors or managers of a site: Focused on the management responsibilities, the commitments and obligations, the risks for the personnel, the financial aspects and the limitations of a measuring instrument or portal monitor.
— Education for interveners with a portal monitor: All the different necessary subjects as described in article 6 of the Royal Decree, the guidelines in practice.
— Education for interveners without a portal monitor: All the different necessary subjects as described in article 6 of the Royal Decree, the guidelines in practice, taken into account that there is no portal monitor installed.
— Training for the site personnel: All the different necessary subjects as described in article 6 of the Royal Decree, with an emphasis on the vigilance procedure.

4.3. Agreements

Because the orphan source issues are cross-boundary, the FANC has to deal with international aspects. Typical examples are the detections of radioactivity in Belgium in shipments from abroad and vice versa. Therefore, Belgium has already had extensive contacts with two neighbouring States — France and the Netherlands — regarding the return of the cargo and the information to the Government. These contacts should finally result in a cooperation agreement. Contacts with other foreign governments seem more difficult and this is certainly a major challenge for the future.

4.4. Awareness and control

Ensuring the implementation on the field is one of the tasks of the FANC. To achieve this goal a multiphase approach is developed:

(a) Phase 1: Identification of the different facilities in Belgium because of the application of the new legal framework.

(b) Phase 2: Informing and raising the awareness of the identified facilities about the new legislation and its consequences and obligations.
(c) Phase 3: Administrative controls (e.g. registration as an OSSF and registration of portal monitors, among other things).
(d) Phase 4: Inspections on the field based on samples, complaints, errors in declaration forms.

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EVOLUTION OF AN ORPHANED SOURCE MANAGEMENT STRATEGY
Canadian experience

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Abstract

During the course of providing regulatory control over nuclear substances, the Canadian Nuclear Safety Commission (CNSC) from time to time has identified sources without an owner or a responsible party. In 2011, after completing a review of its regulatory oversight with respect to orphan sources, the CNSC put in place a strategy that is based on promotion and communication, prevention, and response and recovery of orphan sources. The paper describes the challenges that have occurred during the development of the strategy and the lessons learned during the implementation phase.

1. INTRODUCTION

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials in Canada in accordance with the Nuclear Safety and Control Act (NSCA), in order to protect the health, safety and security of Canadians and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy. During the course of using nuclear substances (or radioactive sources), such material may from time to time become abandoned or lost, requiring the CNSC to bring the material back under regulatory control. In 2009, the CNSC began the development of a formalized management strategy to enhance its regulatory control of orphaned radioactive sources.

2. BACKGROUND

For more than 60 years, the CNSC has regulated the use of nuclear substances (including radioactive sealed sources) across Canada in a variety of applications. Currently, there are over 2500 licences issued by the CNSC for nuclear substances and prescribed equipment that are used in industrial, medical, research and academic environments. Since 2006, the CNSC has been tracking the high risk sealed sources used in these applications through a National Sealed Source Registry (NSSR) and Sealed Source Tracking System (SSTS) as part of Canada's commitment to fully comply with the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [1]. In 2009, an Integrated Regulatory Review Service (IRRS) mission came to Canada and conducted a review of the regulatory framework. One of the recommendations made by the IRRS team was for the CNSC to strengthen regulatory oversight of sealed sources by developing an orphan source recovery programme. The CNSC accepted the recommendation of the IRRS mission and proceeded to conduct a review of how the CNSC exercised its regulatory oversight with respect to orphan sources and how such a programme could be put in place.

A review of existing programmes at the CNSC with respect to orphan sources was conducted by the Directorate of Nuclear Substance Regulation. This directorate is responsible within the CNSC to provide regulatory oversight of the licensing and compliance associated with the use of nuclear substances, radiation devices and other prescribed equipment, which includes activities and equipment such as industrial radiography, portable and fixed gauges, and radiation therapy equipment. All existing measures dealing with orphaned sources were formally documented and any gaps identified were subsequently addressed in the development of the orphaned source programme.

3. OVERVIEW OF THE CANADIAN STRATEGY

What is an orphan source? The regulatory process established in Canada requires that persons who use sealed sources obtain a licence from the CNSC (unless exempt by regulations) and demonstrate that they have the necessary expertise and infrastructure to safely work with them. Licensees are required to maintain an inventory of sources that they have in their possession (Categories 1–5) and obtain the necessary permits to import and export the sealed sources. However, there have been instances where sources have become orphaned and not under proper regulatory control. These can include, but are not limited to, sources that have been abandoned and the owner cannot be located, old sources that precede the requirements for maintaining records of radioactive sources in Canada, sources that enter the country through a metal recycling stream and or incidental importation, or found sources bearing no identification numbers linking it to a specific licensee.

In order to ensure that orphan sources do not present a risk to people and the environment, the CNSC has established a regulatory strategy encompassing the following three elements:

— Regulatory oversight;
— Promotion and communication;
— Response and recovery.

Due to the number of licensees and the numerous locations across Canada where nuclear substances are used, the CNSC has had to adopt a risk informed approach with respect to regulatory oversight. The strategy allows the CNSC to direct staffing and financial resources for the regulation of nuclear substances where they pose the highest risk to workers, the public and the environment. The four primary uses of nuclear substances and prescribed equipment (industrial, medical, research and academic) were categorized into a series of use types that have been further broken down by the level of risk (radiological, safety and security) that they pose. Each of these use types was then ranked as high, medium and low risk with a subsequent regulatory effort assigned to the three levels. High risk categorization would result in an annual inspection, medium risk would be inspected every two or three years and low risk would be inspected on an as needed basis only. The initial risk ranking was performed in 2003 and recently reassessed in 2012. The latest assessment took into account the impact of non-compliance on the health and safety of people and the environment as well as the likelihood of non-compliance occurring in a particular industry, with an updated risk profile established for future implementation. This update will allow the CNSC to better utilize human and financial resources where the focus is needed.

4. REGULATORY OVERSIGHT

The CNSC provides regulatory oversight of the use of nuclear substances and prescribed equipment, through the application of a comprehensive and mature regulatory framework. The regulatory framework is founded on the NSCA and regulations, and comprehensive licensing and compliance verification programmes.

The CNSC exercises regulatory control of sealed source inventories in a number of ways. For Category 1 and 2 sealed sources, the CNSC established in 2006 the SSTS and the NSSR, by which licensees are required under their licence to track the movement of these sources within specified tight timelines. Although there is no requirement mandatory tracking of Category 3–5 sealed sources, licensees are required to report their source inventory (for all categories) annually to the CNSC as part of their annual compliance reports. Licence conditions also restrict the import and export of certain nuclear substances.

The CNSC cross verifies licensee inventories against the NSSR, through compliance inspections and desktop reviews, to ensure that inventories match. In addition, a searchable database separate from the NSSR also maintains information on some Category 3–5 sources. Between the registry and the database, if a found source has any identifying information, it may be possible to identify its owner.

In an effort to minimize the possibility of sealed sources being abandoned by licensees when they are no longer needed or when a business declares bankruptcy, the CNSC has proposed the implementation of financial guarantees requirements for all licensees. The purpose of the financial guarantee will be to ensure that at the end of the operating cycle of either the sources or the company, sufficient financial resources will be in place to safely dispose or manage sealed sources for the long term. The financial guarantee programme initially proposed in 2010 is currently under revision and is planned to be implemented in 2014.

5. PROMOTION AND COMMUNICATION

The majority of orphaned sources discovered in Canada have been found to be in the possession of members of the public or operators of conventional waste management and recycling facilities. Since these groups do not fall within the regulatory oversight of the CNSC, a strategy was needed to address how the CNSC would interact with them. As part of the orphan source regulatory strategy, the CNSC began to develop information to be shared with the above mentioned groups, so that the orphaned sources could be brought under regulatory control. The CNSC web site was populated with general information on radioactive sealed sources, with contact information and some guidance if these groups believed that they were in possession of, or had encountered, radioactive sealed sources.

The CNSC provided more specific information to the recycling and steel industries about identifying and managing orphaned sources. Experience around the world suggested that the most likely industries that would encounter orphaned sources would be these groups. As a result, the CNSC developed and subsequently distributed a poster and an information pamphlet which provide alarm response guidelines for radiation portal monitoring systems. These are available for download on the CNSC web site. The promotional material provides several examples of the types of sources that may be encountered by these industries. The poster and pamphlet encourage industry to deal with alarms by validating the alarm, thoroughly investigating the alarm to rule out the presence of a potential orphaned source and reporting any discovered sources to the CNSC.

In 2011, CNSC staff met with recyclers across Canada to promote these tools and to answer any questions that these stakeholders had regarding nuclear substances and how to handle them when discovered. The Canadian Association of Recycling Industries (CARI) has provided a window for the CNSC to initiate this dialogue and to identify how the groups can maintain a spirit of cooperation. The poster and pamphlet were also shared with steel producers, foundries and waste facilities through various associations. The poster and pamphlet were also shared with the Canadian Border Services Agency, which may detect nuclear substances at ports of entry and border crossings.

In May 2013, the CNSC with the cooperation of both CARI and the Canadian Steel Producers Association (CSPA) initiated a survey to gather additional information from recyclers and steel producers with respect to their detection systems and the types of materials that they have identified.

Discussions with recyclers have identified that for the most part, the majority of radioactive material discovered by industry is naturally occurring radioactive material (NORM). In general, NORM is regulated in Canada by provincial or territorial authorities. Despite the fact that the CNSC does not exercise regulatory control over NORM except in very specific cases (transport, import and export), the CNSC has developed a NORM fact sheet as part of its regulatory strategy, which is available on its web site. This fact sheet provides general information about the regulatory requirements related to NORM, general guidelines for the handling and disposal of NORM, and contact information for each province and territory for questions regarding NORM.

The CNSC reports lost and stolen sealed sources to the IAEA as well as informing CARI, the CSPA, the United States Nuclear Regulatory Commission, Canadian Federal agencies and the joint Canadian Federal/Provincial/Territorial Radiation Protection Committee members. CARI and the CSPA distribute these reports to their members alerting them of a missing source. Companies equipped with radiological detection equipment or systems can increase their vigilance when they become aware of the presence of an unaccounted source. Over the past three years, on average every year 20 sources or devices containing sources (primarily Category 4 and 5 sources) have been reported to the CNSC as being lost or stolen. Typically, all of the high risk sources (Categories 1 and 2) and the majority of the remaining sources are recovered and returned to the original owner or are disposed of safely.

With respect to historic radioactive material, in particular radium luminous devices and historic artefacts, the Canadian Government has been administering a programme over the last 20 years to collect, manage and dispose of such devices, working closely with the CNSC when these materials are discovered and reported. The programme has been very successful in removing such material from the public domain when discovered.

For municipal landfill sites, the identification of lost or stolen sources is much less likely. Nuclear substances that enter the waste stream are primarily open source materials that have been generated by diagnostic and therapeutic medical procedures. For the most part, large landfill sites have developed protocols to deal with these radioactive waste products and can be safely disposed of at such facilities when they meet CNSC exemption levels.

One province in Canada has instituted via regulation the requirement to notify the provincial competent authority when nuclear substances are found entering their facilities. To date, this provision in the legislation has not been enforced but provides another mechanism of identifying potential orphaned or lost radioactive sources.

6. IMPLEMENTATION (RESPONSE AND RECOVERY)

The CNSC works closely with other Federal regulatory agencies across Canada, with licensees and with other industries that may, from time to time, come in contact with materials or cargo containing nuclear substances, orphaned sources or contaminated materials.

The CNSC has put in place internal procedures for dealing with reported events and specifically for the discovery of orphan sources. In all cases, the CNSC becomes involved when an unidentified source is discovered. The CNSC has the ability to identify the nature of the source and the potential risk to public safety that it may pose in its discovered state. If a serial number can be obtained from the source or device, the CNSC will attempt to determine the owner of the source using its NSSR and its database of inventory information. If the owner can be found, the owner is responsible for the cost of recovery or disposal of the source. If an owner cannot be found, currently it is the responsibility of the 'finder' to pay for the recovery or safe disposal of the source. This determination is examined on a case by case basis by the CNSC.

Under the NSCA, the CNSC has the authority to order the owner or the finder of the source to take appropriate action to bring the source or material under regulatory control. This could involve either the transfer of the source to someone who is licensed to possess the source or the transfer to a licensed facility for disposal or long term management. As a last resort, the CNSC will assume control of the orphaned source and provide for the safe disposal should no one be identified that is capable of managing the source.

7. CHALLENGES

The CNSC continues to improve its regulatory oversight of sealed sources to eliminate the possibility of discovering an orphaned source. The licensing and compliance processes have become more and more effective at tracking the movement of high risk sources and cross-verifying licensee sealed source inventory. As the CNSC continues to improve its SSTS, the confidence of identifying all high risk sources in Canada continues to grow. Annual compliance reports submitted by licensees and on-site inspections by CNSC staff are other means of verifying licensee sealed source inventories.

As a result of ongoing business bankruptcies and increased disposal costs for the management of disused sources, there is a concern that more sources will become orphaned. The CNSC currently relies on bankruptcy agencies, trustees, recyclers and conventional industry to absorb the cost for disposal when orphaned sources are identified. The timely implementation of a financial guarantee regime for licensees who possess nuclear substances will go a long way of minimizing the potential for orphaned sources in Canada and assure proper financial resources for their safe disposal.

The financial guarantee regime when implemented will provide the necessary funds where the responsible licensee can no longer assume financial responsibility to manage the sources when they approach their end of life or when the facility using the sources closes or ceases operation.

The proposed financial guarantee regime will apply to all licensees to avoid some from slipping through the cracks and potentially generating orphaned sources. The trustees that deal with insolvent companies, for the most part have been proactive when dealing with sources that may potentially find their way outside regulatory control.

The CNSC continues to work closely with other regulatory bodies both federally and provincially to exercise due diligence in identifying sources and to provide the public with information concerning radioactive material. Despite the implementation of the various measures taken by the CNSC, orphaned source continue to be identified and this supports the requirement of the current programme. There remains the potential of orphaned sources to enter the country by accidental importation through routine cargo or scrap material. The CNSC regulatory strategy in place to manage orphan sources will ensure that they are quickly recovered and pose no danger to the public.

8. CONCLUSIONS

The CNSC has successfully implemented an orphan source management strategy. Orphaned sources are now being effectively brought under regulatory control through this strategy, minimizing the potential risk to the public and the environment. Moving forward, communication between the CNSC and all stakeholders is essential to the continued success of the strategy.

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GLOBAL INDUSTRY PRACTICES AND TRENDS WITH REGARD TO THE DESIGN, USE, RECYCLING AND DISPOSAL OF RADIOACTIVE SOURCES, THE DEVELOPMENT OF NEW AND ALTERNATIVE TECHNOLOGIES, AND ASSOCIATED SAFETY AND SECURITY CHALLENGES

(Session 5)

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D. PERICA
United Arab Emirates

RAPPORTEURS' SUMMARY

Session 5: Global Industry Practices and Trends with Regard to the Design, Use, Recycling and Disposal of Radioactive Sources, the Development of New and Alternative Technologies, and Associated Safety and Security Challenges

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Session 5 consisted of five invited speakers who presented industry perspectives and practices with respect to the design, use, recycling and disposal of radioactive sources, the development of new and alternative technologies, and the associated safety and security challenges. The presentations touched on a number of challenges, including financial assurances for return of sources and the advantages and drawbacks of alternative technologies, which were elaborated upon during the plenary discussion.

Regarding end-of-life management of sources, some participants noted that presently, States have different regulatory requirements for seeking financial assurances by applicants for the return of sources. Participants also noted that often the return of a source is conditional on the receipt of another so the problem is only temporarily addressed.

With respect to the replacement of certain high activity sources in favour of alternative technologies, it was clarified that following the National Academy of Sciences study, no decision was made to restrict the use of ^{137}Cs sources. As a result, the United States Department of Energy has developed enhanced security kits and encouraged replacement of devices using these sources. Some information was also provided on the development of an X ray machine requiring certification of the Food and Drug Administration, which could increase competition in this market.

Other participants noted the need to consider the financial considerations of replacing ^{60}Co devices with linear accelerators (LINACs), since LINACs are generally more expensive, and in the case of developing countries, electricity supply is a challenge.

The following conclusions were drawn from Session 5:

(a) Although the need for sealed sources worldwide remains, alternative technologies (such as LINACs to replace ^{60}Co teletherapy equipment and X ray instead of caesium blood irradiators) are currently being used in some countries and should be considered by others, taking into account the financial constraints and infrastructure of the States currently using radioactive sources or planning to use some.

(b) Industry is making a considerable effort to reuse or recycle sources as much as possible, and options such as 'one-for-one' exchange of sources should be encouraged.

(c) There is a need for nuclear security specialists to have the necessary education, training and certification — a similar approach to that for radiation protection officers should be considered.

(d) A best practice, be it for safety or security, does not have to mean the most expensive solution. This is particularly important for States with limited resources.

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CONTROLLING THE RISK DUE TO THE USE OF GAMMA SOURCES FOR NON-DESTRUCTIVE TESTING AND FIRST FEEDBACK FROM THE DEPLOYMENT OF REPLACEMENT NON-DESTRUCTIVE TESTING TECHNIQUES

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Abstract

Radiographic techniques for industrial inspection have been in use for over 100 years. A key factor in their durability is the ease and effectiveness of the inspection procedure and the resulting optical quality images that give a permanent record and allow multiple interpretations. For an easier implementation, isotopic sources were used in place of X ray generators. Irradiation incidents, which occurred worldwide, reminded the industry and national safety authorities of the importance of controlling the risk connected to the transport and use of gamma sources. In 2005, the French regulator decided to work with industrial companies using non-destructive testing (NDT), on two topics: the development and optimization of best practices during radiographic inspection; and replacement methods to radiographic testing. For the first topic, a working group comprising 60 professionals of all disciplines, chaired by the French Society of Radiation Protection and COFREND worked for two years to help practitioners of industrial radiography to make this activity safer. On the second item, the goal was to produce a recommended practice for companies to determine which inspection technique would meet their requirements and whether it is possible to justify the use of radiography techniques. Different group sponsored projects with industry and laboratories have investigated state of the art NDT techniques. Their main conclusions are summarized in the paper.

1. INTRODUCTION

Radiographic techniques for industrial inspection have been used for many years. A key factor in their durability has been the ease and effectiveness of the inspection procedure and the resulting optical quality images that give a permanent record and allow multiple interpretations during the life span of the installations.

To facilitate their implementation, isotopic sources (i.e. cobalt and iridium) were used in place of X ray generator sets, but this brought a new requirement for safe radiological working protection. Some irradiation incidents, which occurred worldwide at the beginning of the twenty-first century, reminded the industry and national safety authorities of the importance of controlling the risk connected to the transport and the use of gamma sources.

In 2005, the French regulator decided to work with industrial companies using non-destructive testing NDT (i.e. utilities and vendors) on two topics related to this field:

(1) Development and optimization of best practices during radiographic inspection;
(2) Identification of replacement methods to radiographic testing.

The project coordinated by the French Confederation for Non-Destructive Testing (COFREND, Confédération française des essais non destructifs) was planned to last six years, culminating in the development of a generic recommended practice for a safe and efficient performance of radiography in industrial facilities and a methodology guideline to help companies in their options to replace radiographic testing.

One of the main objectives was to define the requirements for many inspections and to understand why gamma radiography is selected rather than another NDT technique. In numerous cases, the use of radiographic testing is more a historic choice (easier to request a radiographic testing inspection than to develop a new solution) or a matter of ease in implementation with no consideration of detection performances.

Different group sponsored projects involving industrials and laboratories have been launched to investigate state of the art NDT techniques and define their advantages and drawbacks as well as their limits. The main conclusions of these Working Groups have been published and are summarized in this paper with some examples of deployment.

The objective of this paper is to present coherent arguments put forward by different actors (i.e. utilities and vendors) to reduce the risk connected to the use of gamma radiography, replace gamma ray sources where possible, or implement a series of good practices and innovations for a reduction in irradiation risks.

2. GOOD PRACTICES TO BE OBSERVED WHEN RADIOGRAPHY IS THE ONLY OPTION

The search for best practices that can reduce the risk of irradiation related to the use of a gamma ray source led the actors to analyse the reported radiographic significant events, which record the non-conformities during exposures, as well as their real or potential consequences. As a result of this analysis conducted annually, the problems associated with personnel restriction zones were identified as the most important ones (zones not marked restricted, operators trapped within a restricted area or voluntary crossing of barriers into it).

On the proposal by the French Nuclear Safety Authority, COFREND and the French Society of Radiation Protection has initiated workshops, bringing together a large number of industrial experts from the fields of gas, oil and nuclear power. The aim was to define best practices to be proposed and deployed nationally to inspection vendors using radiography, to standardize practices and to provide a common reference, in addition to national regulations, on the use of gamma ray sources.

The main themes and results of these workshops are [1]:

(a) An overview of 'general' regulation (i.e. protection against radiation, risk prevention, coordination and handling of radioactive source containers, among other things) with a certain number of specific rules, such as training for the Certificate of Aptitude to Handle the Industrial Radiography and Fluoroscopes (CAMARI), the design of 'gamma radiography' and conditions of use, among other things.

(b) The national feedback from non-conformities and its exploitation: bad control of the exclusion zone, a source locked out of its container due to the presence of dust into the sheath, lack of training for new operators and more generally the human organization factors (i.e. constraints on personnel and night work).

(c) The book review of all the hardware used in industrial radiography (i.e. gamma source container and zone marking), their study and areas of improvement for safety such as:
   - Using a gamma source container, such as the Gammamat SE, lighter and adapted to ^{75}Se, rather than the GAM80 and GAM120, which are heavy;
   - Advocating the mark out Sentinelle (Carmelec) or other light and sound signals that are already in place at French nuclear power plants (see Fig. 1);
   - The systematic use of collimators or equivalent attenuators (see Fig. 2);
   - Advocating the amendment of codes and standards to take into account the use of ^{75}Se.

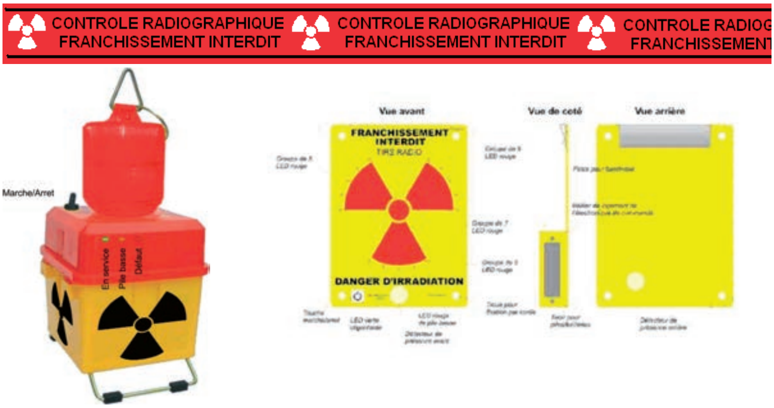

FIG. 1. Mark out Sentinelle (left) and other light and sound signals.

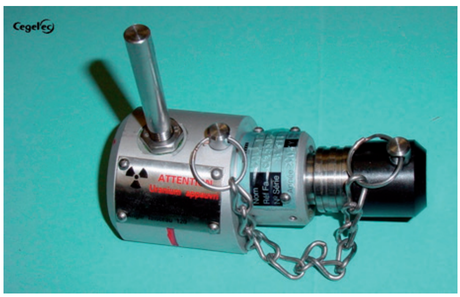

FIG. 2. Directional collimator.

(d) A detailed analysis of the sequences and conditions of work of the personnel involved in radiography to determine the risky jobs — high dosimetry, lack of attention at night and finally setting up a guide for self-evaluation of radiological risk. The principle selected was to carry out a phase division of the various tasks on a building site, by associating each stage to the inherent risks. Gamma ray NDT are activities which require a vigilance at every moment:
- To make sure of the quality of work;
- To manage the various risks including the risk of exposure to ionizing radiations;
- To fight against falls of attention dependent on the forms of tiredness, the work conditions, the difficulties of access and in certain cases to night work, among other things;
- To manage temporary pressures (i.e. audits and monitoring);
- To manage the coerciveness to avoid exposing other professionals;

— To manage the coactivity in the neighborhood of work (presence of hazardous substances).

The field of study of an analysis of risk covers trade, tasks and activities, harmful effects and risks. The principal framework identified is the distribution of the responsibilities between:

— Utility: customer;
— Project superintendent;
— Vendors: intervening company in radiography.

It points out certain obligations and proposes ‘good practices’ received from industrialists of the field. It is initially advisable to clarify the strong points which define this distribution of responsibilities. This one is based initially on a contractual relation between the two or three stakeholders. The customer thus entrusts both the project superintendent and himself with the responsibility for surveying the vendor while he performs inspection services in accordance with legislation and the conditions of optimum safety. Each entity is therefore aware of its own responsibilities, this being the fundamental base and therefore impossible to circumvent the operational objectives and of safety.

The recommendation is to make a good radiographic inspection in one shot to avoid the unnecessary repeating of the source being unwound which could become an environmental hazard if problems occur when winding the source back into the source container.

The use of a collimator can significantly reduce the irradiated area upstream of the source, and thus reduce the exclusion zone extent, allowing other work streams to take place in neighboring locations.

3. REPLACEMENT METHODS

3.1. COFREND

COFREND decided to produce a recommended practice for companies to determine which inspection technique would meet their requirements and whether it is possible to justify the use of radiography techniques. A step by step questionnaire is used to help define the specification of inspection objectives and gauge whether it is possible to implement alternative techniques.

The goal of weld inspection is to detect construction and fabrication flaws, or service degradation, that may impact the structural integrity of the welded component. Common weld fabrication flaws include cracks, lack of fusion, incomplete penetration and volumetric inclusions such as slag and porosity. Thermal or mechanical fatigue and stress corrosion cracking are typical of service related degradation.

Prior to inspection, it is important to have a list of the input data that is required to write the inspection specifications [2]:

- The objectives of the inspection;
- A full description of the component(s) to be non-destructively tested, including material, surface finish and access;
- Type, dimension, orientation, location and morphology of defects to be detected or sized, depending on the defect situation considered;
- The inspection performance (detection, sizing and location) to be achieved;
- ALARP (as low as reasonably practicable) consideration if applicable (by reducing isotope energy using selenium or digital radiography).

Whilst the above list provides a useful guide, it is not exhaustive and more detailed information is required to fully define the inspection requirements. The utility needs to define the requirements of the inspection with clear and pre-established functional specifications (objectives of the inspection). A lax definition of the inspection requirements could lead to an inadequate inspection thus breaking the transition to others techniques.

Multipartner projects have been launched since 2005 with special interest in advanced technologies like digital radiography, ultrasonic testing time of flight diffraction, phased array ultrasonic testing and developing a long term timeline or roadmap that attempts to predict utility needs and match them with future technological advances.

The objective of these working groups was to continue to develop and refine the long term plan for filmless radiography by adjusting the milestones of current projects and the long term plan to reflect member utility needs and by proposing new projects that address emerging technologies, code revisions and regulatory issues.

3.2. ALTER'X

ALTER'X is a project led by the French Welding Institute, whose objectives were to identify credible alternatives to industrial radiography using ^{192}Ir for welds used in pipe manufacture, to decrease significant operational dosimetry exposure to inspection personnel [3].

The key steps of the project were:

(a) To use state of the art NDT techniques, specifically applicable to welds, and identify their advantages, disadvantages and limitations.
(b) To evaluate the applicability of the most promising techniques such as X ray tubes with new X rays, digital radiography with the latest generation of phosphor plates, fluoroscopy screens or C-MOS silicon amorphous, use of ^{75}Se, time of flight diffraction testing, phased array ultrasonic testing and advanced ultrasonic techniques. The choice of techniques to experiment was conducted by common consent with the participants at the end of the embodiment of the prior art.
(c) To set tasks for the various testing techniques used, applicable areas and limitations of these techniques as a function of the geometrical characteristics of the component to be inspected: diameter, thickness, close to the weld in the case of a T or elbow or geometric variation (misalignment).
(d) To develop recommendations for the most promising general NDT techniques. These recommendations will be proposed to the reference participants.

3.3. MANUREVA

The MANUREVA project, Multi Actors NUmerics Radiographic EVAluation [4], is a R&D collaborative study grouping four industrial end users (DCNS, IS Industry, STX France SA and Électricité de France (EDF)) and a classification society (Bureau Veritas). The objective of this project is to identify computed radiography inspection systems using imaging plates that meet end users specific needs and to evaluate their performance. As part of the ISO 14001, the MANUREVA project aims to limit the environmental and human impact of industrial radiography by taking advantage of the recent advances in digital phosphor plate detectors including no chemical development constraints of silver films (effluent treatment) and flexibility of implementation (real time scanning and digital exchange).

3.4. AREVA–Électricité de France

Since 2006, AREVA has been evaluating the performance of computed radiography against conventional radiographic testing in the framework of EN 14784 for the digital part and the RCCM code for the conventional one. The objective was to build a technical justification report to eventually support introduction of computed radiography into the RCCM code.

In 2009, the subject gave rise to collaboration between AREVA NP–NETEC and EDF–CEIDRE, for a joint project to establish performance limits of computed radiography towards EN 14784 specifications and RCCM code image quality indicator requirements to demonstrate the current state of achievable image quality in computed radiography. The performance has been evaluated for steel with a thickness range of 20–60 mm using an ^{192}Ir gamma source. Image quality has been assessed in terms of EN 462 and ASTM (E747, E1742) image quality indicators. The results have been scored considering the PR ISO 17636-2, RCCM 2007 and ASME V-2010. This also permitted comparison between the different standard requirements [5].

3.5. CETIM–IS–AFIAP–COFREND–SNCT

A working group representing the pressure vessel equipment profession and composed of COFREND, Association française des internes et assistants de pathologie (AFIAP), Sociète national de contrôle technique (SNCT), the Technical Centre for the Mechanical and Electrical Industries (CETIM, Centre technique des industries mécaniques et électriques) and Institut de Soudure was created to write a common document gathering a part of the results obtained by CETIM and Institut de Soudure [6].

The document produced in the field of the common work is in the form of a technical book, and aims to answer the following question: How practically, at the manufacturing or mounting stage, can industry substitute to iridium radiography new testing methods or techniques?

The document is a complement to COFREND document Demarche de justification de la radiographie gamma [2] (justification of gamma radiography) and consists of a synthesis of knowledge and practice of the writers, with the objective to address the needs of various industrial actors:

— To be practical;
— To enable the customer to have a satisfactory implementation of alternative NDT methods chosen after application of the manual recommendations;
— To define the framework for using these methods/techniques while ensuring equivalent service quality.

In the document is hence proposed a methodology to help the decision process to use an alternative technique to radiographic testing:

— Balance plus–minus value of novel technique compared with the previously used, changes and consequences of using this new technique: organization, means, manufacturing process.

— Time and cost factors.
— Impact of changes on NDT operators — training and skills.

4. WHERE WE ARE? DIFFICULTIES IN REDUCING THE DEPLOYMENT OF RADIOGRAPHIC TESTING TECHNIQUES

It is obvious that NDT is only part of the global maintenance strategy of the utilities. In this context, the driver for utilities is the reduction of the risks connected to gamma radiography, which has been described above, plus the optimization of maintenance strategies to decrease the NDT applied during in-service inspection. The main gain for reducing the use of radiography is to reduce the NDT carried out on plants [7].

Replacing a NDT technique with another one can be complicated. Each technique or method has its advantages and drawbacks, as well as different performances in terms of detection, positioning and classification and/or characterization of the detected flaws. While radiographic testing and ultrasonic testing are both volumetric non-destructive evaluation (NDE) methods, the physics of these processes are substantially different. Radiography relies on transmission and absorption/attenuation of small wavelength electromagnetic waves (X rays and gamma rays). Ultrasonics, on the other hand, relies on the interaction of acoustic wave energy with discontinuities in the inspected material.

Formalizing an action to assess, as objectively as possible, the relevance of replacing a NDT technique or method, is becoming more and more necessary. In fact, replacing ^{192}Ir gamma source radiography has been a concern for an increasing number of users in Europe and several important documents have been published [6, 8]. It is important now to propose alternative techniques for piping welds testing at the manufacturing stage determining scope of applications, limits and performances compared to those of ^{192}Ir gammagraphy.

After the physical phenomena used, sometimes, it is difficult for only one NDT technique to completely replace gamma radiography. The two best established NDT methods used for volumetric inspection of welds are ultrasonic testing and radiographic testing. A number of parameters influence selection of the method: technique requirement, accessibility, safety considerations and historical inspection schemes, but today the two most influential factors are code requirements and economics.

There are clearly gaps in the codes and standards and guidance is needed for using ultrasonic testing in lieu of radiographic testing. Acceptance criteria in codes and standards are a relevant example of this situation. Using acceptance criteria for ultrasonic testing based on radiographic testing criteria (workmanship standard) is not the solution because the physical laws governing these two methods are very different.

Acceptance standards for fabrication are based on radiographic testing workmanship standards and not on fitness for service. Flaw acceptance and rejection criteria are based only upon the length of the indication and not on the through wall size or through wall location of the flaw. Typically, radiographic testing is used versus ultrasonic testing for fabrication inspections. Acceptance standards for pre-service inspections and in-service inspections are based on fracture mechanics. Typically, ultrasonic testing is the preferred choice versus radiographic testing for these inspections.

Not to mention performance demonstration: we are now more and more obliged to make a capability assessment of alternative techniques before implementing them on site during outages [9, 10]. In addition, the inspection companies and regulatory authorities need to fully accept that no one technique can be used in isolation and each has its benefits and limitations. Inspection design has to encompass the requirement to use a multitechnique approach in many cases which will provide a fit for purpose inspection.

5. CONCLUSION

Utilities undertook a global and fast initiative to reduce the number of gamma exposures bound to NDT within the last five years (replacement and limitation of exposures); reducing the associated risks has been for them an opportunity to decrease the cost and to optimize the planning of in-service inspection.

Furthermore, there are many situations where radiography is the most appropriate and most efficient NDE technique. For these cases, the use of less powerful gamma ray or X ray sources and the implementation of good practices by the operators can highly reduce the risks of irradiation exposure to people.

For the evolution of protection against radiation, we tried **the increased integration of the social, organizational and human aspects**. In the future, each actor of the process has the duty to perpetuate this work so that all, including the industrialists working in very diverse sectors, should have an identical standard level.

The subject of replacing radiography in ^{192}Ir is obviously not closed. Stakeholders involved in the implementation of NDT have each to adjust and to optimize for their specific industry sector, with the tools identified in this recommendation.

Nevertheless, it is important to know that this kind of studies undertaken in industries worldwide reach the same conclusions and recommendations [11]:

— Ultrasonic testing in lieu of radiography is feasible.
— Ultrasonic testing acceptance criteria need to be defined in fitness for service and not only in workmanship standards.
— Ultrasonic testing capability assessment needs to be carried out.

This is the main reason for the slow replacement of radiography by other inspection techniques.

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A REVIEW OF THE US NATIONAL ACADEMIES REPORT ON RADIATION SOURCE USE AND REPLACEMENT

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Abstract

In 2008, the US Congress asked the National Academy of Sciences (NAS) to form the Committee on Radiation Source Use and Replacement. The NAS Committee was tasked with reviewing prospects for replacing IAEA Category 1 and 2 radionuclide sealed sources with less dangerous alternatives. The NAS Committee found that non-radionuclide replacements existed for nearly all Category 1 and 2 radionuclide sources in varying degrees of readiness. However, after reviewing the overall risks associated with radioactive caesium chloride (CsCl), the NAS Committee felt it was urgent to take near term action on CsCl sources. The Committee recommended that the US Government should implement options for eliminating Category 1 and 2 CsCl sources from use. The paper provides an overview of the risk based methodology that was used by the NAS Committee in formulating this recommendation.

1. INTRODUCTION

The US National Research Council formed the Committee on Radiation Source Use and Replacement at the request of the US Congress. The Committee was tasked with reviewing prospects for replacing IAEA Category 1 and 2 radionuclide sealed sources with less dangerous alternatives. The statement of task to the Committee is as follows [1]:

> "The principal task of this study is to review the current industrial, research, and commercial (including medical) uses of radiation sources to identify uses for which:
> (1) the radiation source can be replaced with an equivalent (or improved) process that does not require the use of radioisotopes; or

(2) the radiation source can be replaced with another radiation source that poses a lower risk to public health and safety if it is involved in an accident or used in a terrorist attack."

This paper will review the key recommendation of the Committee, which was to begin the phase-out of caesium chloride (CsCl). This recommendation was made after considering the radiological terrorism risk that is posed by those devices which employ CsCl. In this paper, the chemical formula CsCl refers to caesium chloride salt enriched with the isotope ^{137}Cs.

2. RISK, RADIATION DISPERSAL DEVICES AND AREA DENIAL CONSEQUENCES

One of the main motivations for the NAS Committee study was to explore the feasibility of reducing the availability of high risk radionuclide sources and thereby reduce the potential for a terrorist group to illicitly acquire and use them for malevolent purposes. The consideration of risk was therefore a fundamental element to the study. In considering the risk of malevolent use, the Committee focused primarily on the risk of developing and deploying a radiation dispersal device (RDD). This was after consideration of the likelihood and impact of other types of radiological terrorism as presented in Table 1.

TABLE 1. OPTIONS FOR RADIOLOGICAL TERRORISM

Device type	Dispersal form	Economic effects	Health effects	Comments; impact
Radiation exposure device (RED)	n.a.[a]	Low to medium	Medium: deterministic and stochastic health effects	No lasting economic impact
Rad-food dispersal (RFD)	Dissolve or mix	Medium to high	Medium to high: deterministic and stochastic health effects	Other poisons more readily available
Radiation dispersal device (RDD)	Many	Medium to very high: "area denial"	Low: latent cancer risk (stochastic) drives population relocation	Could impact ~10 000s Area denial — unique aspect of radiological material

[a] n.a.: not applicable.

Creation of a radiation exposure device (RED) could involve simply taking a stolen radiation source and placing it in a public place with a high level of pedestrian activity. It is the least complicated scenario (no dispersal mechanism required) and a high activity (Category 1 source) could cause serious radiation induced illness (including death) to those individuals that happen to pause near the source for a few minutes. More likely is that hundreds to thousands of individuals could be exposed to lower levels of radiation resulting in increased latent cancers. A large gamma ray emitting radiation source is readily detectable with hand-held radiation pagers and this scenario is likely to be detected quickly in any major US city where police officers and other first responders are equipped with radiation detection equipment.

Food and water poisoning is possible with certain forms of radioactive material, but this is not unique and other common poisons are more readily available and easier to use.

Finally, there are RDDs, which involves the spreading of radiological material, most commonly with explosives. Studies and experiments have shown that it is difficult to cause serious health injury with RDDs and that the hazard boundary for prompt, deterministic health effects for a realistic explosive RDD extends outward roughly of the order of 100 m from the explosive device [2, 3]. The more serious consequence and a unique aspect of the RDD is its ability to cause economic damage due to the need to quarantine a much larger area and to clean up associated contamination. The much larger quarantine area is determined not by the risk of prompt deterministic health affects but instead by the perceived risk of latent stochastic effects, such as cancer.

Figure 1 shows a graphic depiction of a typical explosive RDD. Highlighted in the figure are the dose pathways to individuals that happen to be exposed to the radioactive debris cloud as it passes overhead. Beyond the ‘near field’ zone (10–100 m) for prompt health effects there will be a fairly large zone for late, stochastic health effects, extending for perhaps kilometres in range. Just how large this zone of area denial becomes will depend on the particulars of the RDD, wind speed and other weather conditions, as well as the interplay between the government authorities and the affected public, who will need to settle on a cleanup plan. The public’s perception of the risk of exposure to radioactive contamination and the responsible government’s ability to communicate the true risks, as well as they are known, will factor into the cleanup decisions.

Indeed, it is this complex human interaction along with the fear and uncertainty as to the effects of low level chronic exposure to radiation that makes the RDD threat so pernicious and that could drive cleanup thresholds well below what would be scientifically and economically justified. Some of the

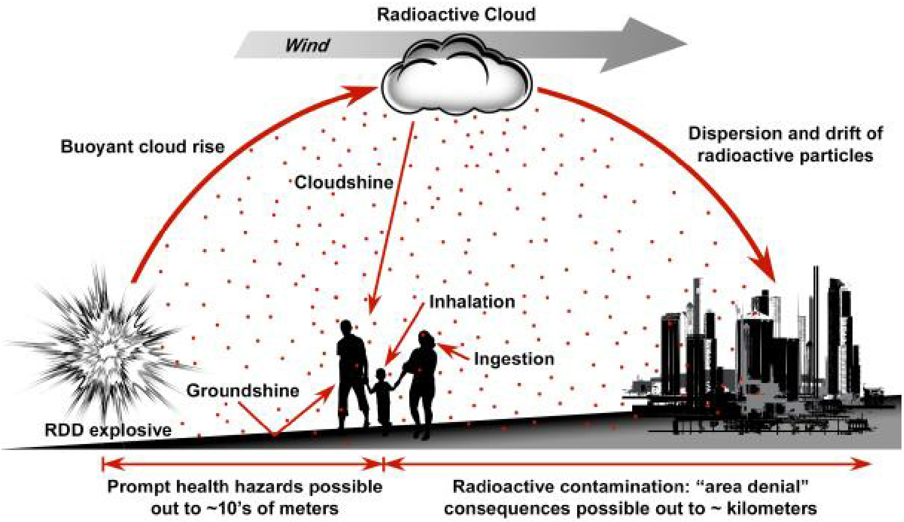

FIG. 1. The RDD produces area denial consequences.

qualitative factors that the public may consider in examining the risk of exposure to radioactive contamination are as follows:

- — Understanding of risk;
- — Trust in government information;
- — Short term versus long term risk;
- — Personal control of risk;
- — Benefit/cost of risk;
- — Seen versus hidden risk;
- — Equitable sharing of risk.

When examining the risk posed by an RDD, terrorism analysts will consider the factors as outlined below in Fig. 2. In examining the risk posed by the Category 1 and 2 radiation sources the NAS Committee primarily considered the probability of source material acquisition. This was explored qualitatively by the Committee by examining the availability and perceived vulnerability of particular radiation sources to illicit acquisition. Based on the above discussions, the Committee also focused primarily on the economic consequences resulting from the 'area denial' consequence. This focus led to a consideration of the chemical/physical form of the source material as well as the total activity of a source available for acquisition.

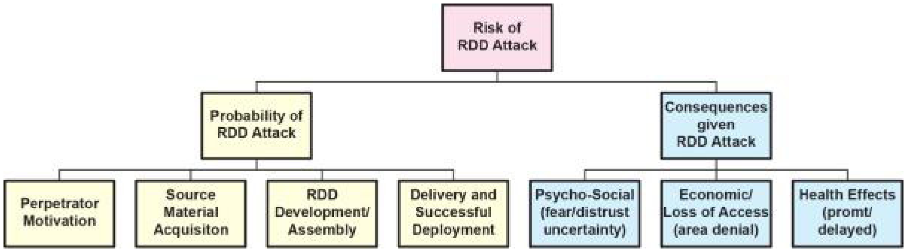

FIG. 2. RDD risk decomposition into fundamental factors.

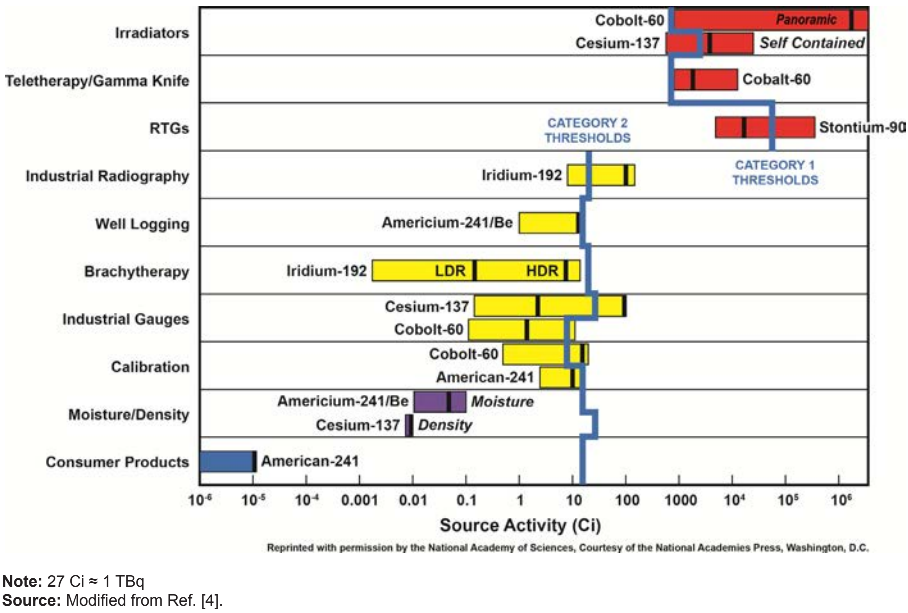

FIG. 3. Radiation source applications, radionuclides and activity ranges.

3. CATEGORY 1 AND 2 DEVICES AND RADIONUCLIDES EXAMINED IN A NATIONAL ACADEMY OF SCIENCES STUDY

3.1. Category 1 and 2 devices

Figure 3 presents a chart derived from IAEA Safety Standards Series No. RS-G-1.9, Categorization of Radioactive Sources [4]. The coloured bars represent the activity range typical for the labelled devices with the black lines representing the typical activity. The radionuclide label applied to each bar is the most typical radionuclide used in the application. The blue lines overlaid on the chart depict the Category 1 and 2 thresholds for the particular radionuclide listed as the dominant radionuclide for that application.

The Category 1 devices include large panoramic irradiators used for sterilization, smaller self-contained irradiators used for research and blood irradiation, teletherapy and gamma knife devices used in cancer therapy, and radioisotope thermoelectric generators (RTGs) used for remote power. The most common Category 2 sources and devices are the calibration irradiators, well logging sources and industrial radiography cameras.

Figure 4 presents images of some of the most common Category 1 and 2 devices and their sealed sources that the Committee examined for potential replacement. These are devices whose state of use and wide availability make them more likely candidates for illicit acquisition. The top row shows two Category 1 devices, a teletherapy machine which typically uses ^{60}Co and a self-contained irradiator which can use either ^{60}Co or ^{137}Cs. The teletherapy and self-contained irradiator sealed sources are also shown in Fig. 4 alongside the device. These devices are found at facilities such as hospitals and universities. The two devices on the bottom row represent portable sources, important to consider when assessing vulnerability to illicit acquisition. Radiography cameras typically use ^{192}Ir sources and well logging sources are usually ^{241}Am, which, when mixed with beryllium, produces a neutron output.

Self-contained irradiators will be discussed in more detail below. They are used for performing radiobiological and medical research and for blood irradiation each application having a separate and distinct user community. The difference in size and design between these two irradiator types is not significant, and it often occurs that a hospital blood irradiator is donated to a university for use as a research irradiator.

3.2. Category 1 and 2 radionuclides and their area denial properties

From the previous discussion, it is clear that the radionuclides employed in the most common Category 1 and 2 sources are: ^{60}Co and ^{137}Cs for Category 1 devices: and ^{192}Ir and ^{241}Am for Category 2 devices. These were the principal radionuclides and applications considered by the Committee. Some of the key properties of these radionuclides are presented in Table 2.

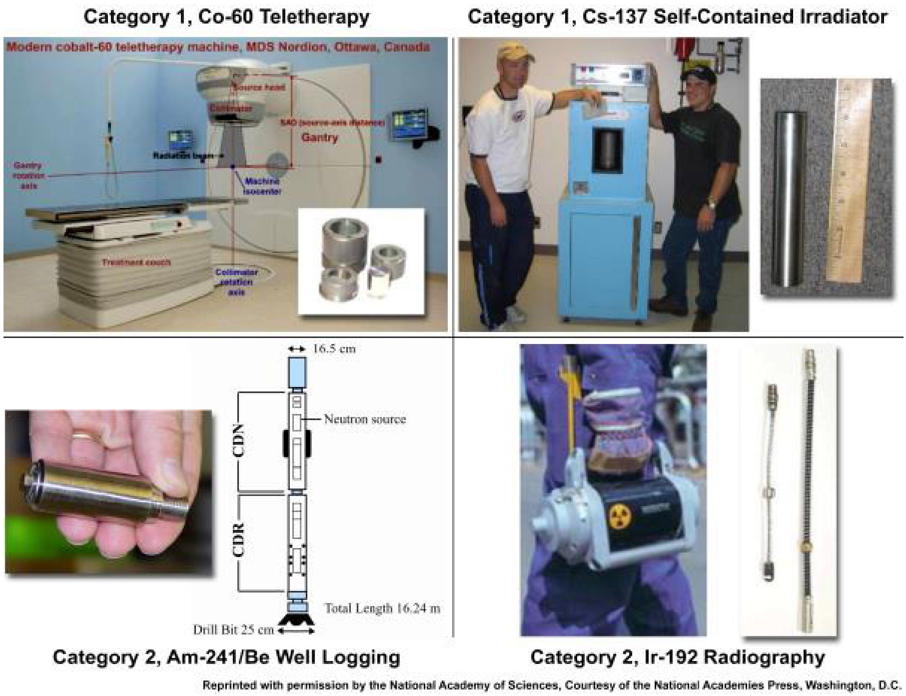

FIG. 4. Sample of the Category 1 and 2 devices studied by the Committee.

TABLE 2. SUMMARY OF THE MOST COMMON RADIONUCLIDES USED IN CATEGORY 1 AND 2 SOURCES AND DEVICES

Radionuclide and emission	Half-life	Chemical form (typical)	Power to contaminate (TBq/km^2)	Typical application and activity
Co-60 (β,γ)	5.3 years	Metal	0.37	Category 1 Irradiators Teletherapy ≥ 37 TBq
Cs-137 (β,γ)	30 years	Salt (CsCl) powder	1.5	Category 1 Irradiators ≥ 37 TBq
Ir-192 (β,γ)	74 days	Metal	3.7	Category 2 Radiography ≥ 3.7 TBq
Am-241 (α,γ)	430 years	Oxide powder	1.5	Category 2 Well logging ≥ 0.37 TBq

From the perspective of radiological terrorism risk, the fourth column of Table 2 presents an important parameter — the ‘power to contaminate’. This is the amount of source material activity that would need to be uniformly dispersed over 1 km^2 in order to cause an exposed individual to receive a dose of 20 mSv in the first year, post dispersal, from either ground-shine or inhalation of resuspended material. This value, “20 mSv in the first year”, is from the recommended Protective Action Guideline (PAG) for population relocation as defined by the United States Environmental Protection Agency (EPA) [5]. The TBq/km^2 numbers presented in Table 2 are approximate. Of course, an explosive RDD will not create a uniform dispersal, so these values are an idealization of the dispersal problem, but they are nevertheless useful because they define a threshold activity under perfect dispersal which removes the complexity associated with the mechanism of dispersal, the weather conditions and other factors. This allows us to examine the quantity of radionuclide needed to cause an ‘area denial’ condition over 1 km^2, assuming perfectly uniform dispersal. Table 2 shows that for these commonly used radionuclides a quantity on the order of 1 TBq represents a significant quantity for area denial, which is in rough ‘order of magnitude’ agreement with the threshold activities of a Category 2 source (for these radionuclides).

The ability to disperse material is a function of the chemical and physical form of that material, which is presented in the third column of Table 2. Here we see that ^{60}Co and ^{192}Ir are used in metal form, while ^{137}Cs is used in the salt form (CsCl) and ^{241}Am is an oxide powder that, as described previously, is mixed with beryllium powder and pressed into a pellet.

Finally, the half-life of the radionuclide is an important consideration from the area denial perspective. A relatively short half-life radionuclide, say a few days, would pose less area denial risk in that one could simply wait out the problem and not have to initiate decontamination, provided the daughter species is non-radioactive or is also short lived. Half-life is also related inversely to the ‘specific activity’, or activity per unit mass, of the material, with a longer half-life corresponding to a greater mass needed for a given activity. Other factors also contribute to the actual specific activity of a particular radionuclide, such as the presence of inert material (e.g. the chloride in CsCl) and other impurities and for neutron activated materials (^{60}Co) the fraction atoms undergoing activation.

4. RISKS FACTORS POSED BY CATEGORY 1 AND 2 CsCl SOURCES

In Section 3, it was noted that ^{137}Cs applications involve Category 1 self-contained irradiators, used in research and blood irradiation. These devices typically contain greater than 37 TBq of ^{137}Cs in the salt form (CsCl). This was

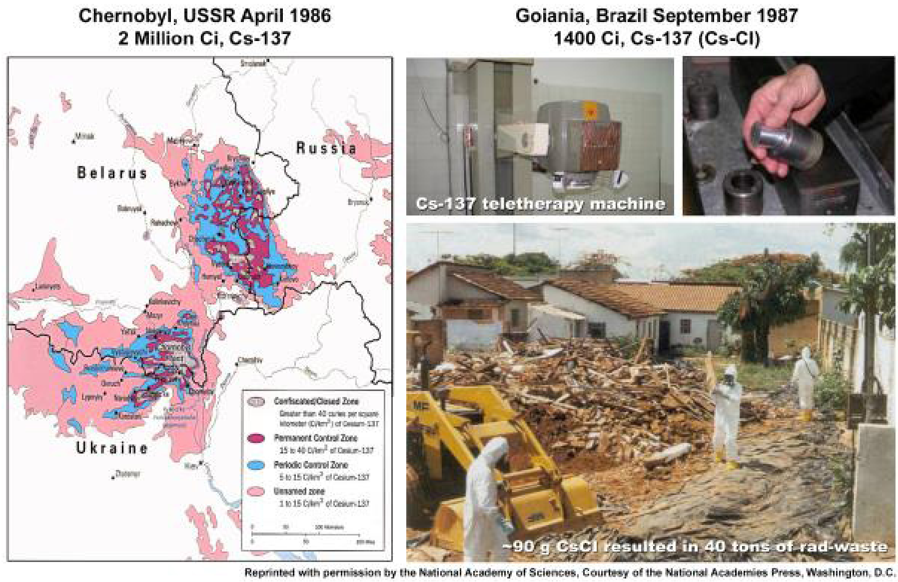

FIG. 5. Past accidents involving ^{137}Cs.

one of the issues that concerned the Committee regarding CsCl RDD risk; the size of a typical CsCl source is 100 times the power to contaminate. A second issue concerning ^{137}Cs and CsCl in particular was the difficulty of decontamination that was known from past accidents involving this radionuclide. Two particular past accidents involving ^{137}Cs are reviewed below and shown in Fig. 5.

In order to form an appreciation of the potential effects of an RDD incident involving ^{137}Cs, two accidents are particularly relevant: the reactor accident at Chernobyl [6] and the dispersion accident in Goiânia, Brazil [7]. At Chernobyl, Ukraine, a nuclear power reactor in 1986 suffered a loss of control accident during a test. The runaway reactor produced a large amount of hydrogen, which exploded and tore the roof off the reactor building. The reactor caught fire and burned for four days, spreading radionuclides over large distances. While much attention has been given to the spread of radioactive iodine isotopes, due to the delayed stochastic thyroid risk to children, another equally serious and persistent consequence has been the dispersion of ^{137}Cs. Large areas were contaminated by this radionuclide and closed to the public. Soviet attempts at a cleanup were unsuccessful. Confiscated zones were defined and over 200 000 inhabitants were forced to relocate from these areas. These zones are shown above in bright red. These areas were contaminated to a level of 40 Ci/km^2 (1.5 TBq/km^2) or above, which is the same criteria used in the EPA PAG for relocation (i.e. 20 mSv in one year). While 2 000 000 Ci (70 000 TBq) of ^{137}Cs, the amount released by the accident, is much larger than any credible terrorist RDD, the issues involved are basically the same. Caesium-137 by virtue of its chemistry (Group I of the periodic table) is an alkali metal, a very reactive element that will chemically bond with many substances, thus making it very difficult to cleanup. Although the ^{137}Cs in the Chernobyl fallout was not CsCl, once it is deposited into the environment, the effects are similar.

The second accident, in Goiânia, Brazil, which occurred in 1987, is more representative of the scale of a terrorist RDD incident. A teletherapy machine containing 1400 Ci (52 TBq) of ^{137}Cs was left in an abandoned medical clinic. Scrap metal scavengers gained access to the facility and removed the therapy head containing the CsCl source. They sold the heavy metal therapy head (and source contained within) to a salvage dealer, who later disassembled it, removed the CsCl source capsule and pierced the capsule window thus exposing the CsCl powder. A CsCl teletherapy machine similar to the one in the Goiânia accident is shown in Fig. 5, along with the source capsule. The salvage dealer, not knowing what he had found, was intrigued by the glowing blue powder and showed it to his family and friends who became contaminated and inadvertently spread the contamination. Due to its solubility, the CsCl became widely dispersed throughout the city, mainly by the motion of people and cars, among other things (cultural dispersal). The CsCl became chemically bound to material surfaces resulting in the required use of destructive decontamination, as seen in Fig. 5.

It is instructive to note that a similar accident involving a teletherapy machine occurred in Juárez, Mexico, in 1983 [8], the difference being that the teletherapy machine in Juárez contained a source of ^{60}Co pellets instead of CsCl powder. In this instance, the ^{60}Co source pellets that were accidently scattered on the ground were found with a radiation detector and promptly removed with no significant economic consequence. This clearly illustrates the significant area denial risk differences posed by a soluble powder (CsCl) in comparison to an insoluble hard metal (^{60}Co).

Another risk related issue of concern to the Committee was the widespread use of CsCl self-contained irradiators in the United States of America. There are approximately 1000 CsCl self-contained irradiators in the United States of America [1]. These are found in major US cities, hospitals and universities. Universities in particular have a cultural mindset of openness and academic freedom, which is generally at cross-purposes to the security culture one would like to instil with CsCl irradiator use. Hospital security is often better than at universities, but the application of blood irradiation is a near continuous operation, which is conducted generally in an unsecured area of the hospital or blood bank with many other ongoing activities, a difficult environment in which to impress physical security. Worldwide estimates (compiled by the authors) obtained from data provided by CsCl device manufacturers, distributors and preventative maintenance operators indicate roughly an equal number of CsCl irradiators worldwide; that is, another 1000 machines with no single State having significantly more than approximately 100 CsCl machines in use.

5. SUMMARY

It was the combination of these risk factors that strongly contributed to the NAS Committee's recommendation of near term phase out for CsCl:

(a) The quantity of CsCl used in self-contained irradiators being large relative to the quantity needed for a significant area denial event;
(b) The dispersability of the CsCl powder relative to the hard metals used in other Category 1 and 2 radionuclide applications;
(c) The deleterious consequences of past accidents involving ^{137}Cs;
(d) The wide availability of CsCl irradiators;
(e) The relative difficulty of providing and sustaining security at the facilities where the CsCl irradiators are located.

In the five years since the National Academy of Sciences report was published, the US Government is continuing to explore options to reduce the risk associated with CsCl. An outright ban on the use of CsCl has not been pursued in the United States of America. Many of the CsCl irradiator users believe that the available X ray machine alternatives provide a less viable option compared to the existing CsCl irradiator which they already possess. The US Government has supported research in alternative, non-radionuclide technologies and has also funded side by side comparisons between X ray and CsCl irradiators for some research applications [9]. In the interim, the US Federal Departments of Energy and Homeland Security and the United States Nuclear Regulatory Commission have collaborated in developing special security enhancements to the CsCl irradiators in use in the United States of America.

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EXPERIENCES IN RECYCLING AND REUSE OF RADIOACTIVE SOURCES IN BRIT

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Abstract

The Board of Radiation and Isotope Technology (BRIT), a unit of the Department of Atomic Energy in India, produces and supplies various types of sealed radiation sources in India. The sealed sources include teletherapy sources using ^{60}Co, industrial radiography sources using ^{60}Co and ^{192}Ir, nucleonic gauging sources using ^{60}Co, ^{137}Cs, among others, and ^{137}Cs brachytherapy sources. BRIT has acquired considerable experience in the reuse and recycling of these sealed sources. This has proved to be very useful in continuous control of these sources over the life cycle.

1. INTRODUCTION

Sealed radioactive sources of radioisotopes such as ^{137}Cs, ^{60}Co and ^{192}Ir are extensively used for varied applications in medicine, industry, agriculture and diverse research fields throughout the world. Each source is indispensable for enabling unique applications where other means are not available. The sources vary widely in physical size, properties and their radioactivity level. Once their certified useful life is over, the sealed sources containing radioisotopes pose an inherent risk from liability, safety and security angles owing to the possibility of inadvertent or deliberate misuse of the radioactive materials. Hence, the security of such unused sealed sources is of concern, particularly due to the potential of using such sources for malevolent purposes such as radiological dispersal device or 'dirty bomb'. Post 11 September 2001, the concern about the deliberate dispersion of radioactive material to cause panic and chaos has further grown. It can be assumed that all radioactive sealed sources can be used as a dirty bomb. Cobalt-60 and ^{192}Ir exist as solid metals and would not be readily dispersible. Caesium-137 is probably the largest threat, as it was often used as a fine caesium chloride (CsCl) powder, which is easily dispersible in aerosol form and is soluble in water. It is a hard gamma emitter, has a half-life of 30 years, with high radiological threat, and once contaminated, its cleaning is extremely difficult. The safety of the disused ^{137}Cs, ^{192}Ir and ^{60}Co sources is also a subject of concern as the accidental release of radioactivity from the sources could also result in widespread contamination. The example is the Goiânia accident in which the ^{137}Cs source was stolen from an abandoned hospital in the Brazilian city of Goiânia and subsequently handled by several people. They suffered serious contamination, resulting in several deaths and injuries. The probability of such events is more with unused sources stored.

Sealed radiation sources are of concern from two angles. The safety aspect is addressed to minimize the probability of radiation exposure to personnel. On the other hand, the security of a source aims at preventing any unauthorized possession and malevolent actions with the source. The measures to render a sealed radioactive source safe as well as secure are generally taken by the manufacturers, laying stress on safety as the primary concern. In this context, unused sealed sources if tampered open could be a cause for security concern. All sealed ^{137}Cs and ^{60}Co sources currently in use will eventually become disused but will be returned back to the source manufacturer. The inventory of disused sealed sources is likely to be increased in future at source manufacturer's end. In the past, most of the sealed ^{137}Cs sources used in India for various applications were procured from overseas suppliers and these contained ^{137}Cs in the form of ^{137}CsCl. Once their certified life is over, these unused radioactive sources were directly sent to our center for surveillance and management purpose. Owing to the liabilities involved in the storage and disposal of sealed sources, efforts are being made to transfer them to an engineered storage facility, where it can be safely allowed to decay with significant economic burden. Alternatively, they could be recycled and used in the preparation of industrial and medical sources of lower activities. Taking into account the cost of storage (capital cost and annual operational cost) as well as the cost of fresh activities, recycling and or reuse of the disused sources was considered economically a better option for India where there is an active sealed sources programme. Thus, it was decided to recycle many of the possible sealed sources from the disused source rather than disposing it, as recycling reduces the security liabilities as well as financial burden of procuring fresh sources. The practice of recycling the sealed sources from high activity sealed sources post-expiration is known to be followed by some manufacturers. The recycling or reuse of the sealed sources in the Board of Radiation and Isotope Technology (BRIT) using ^{137}Cs, ^{192}Ir and ^{60}Co is discussed below.

2. TELETHERAPY SOURCES USING ^{60}Co

The curie content of a teletherapy source varies in the range of 222–444 TBq (6000–12 000 Ci). Fabrication of these sources involve double encapsulation

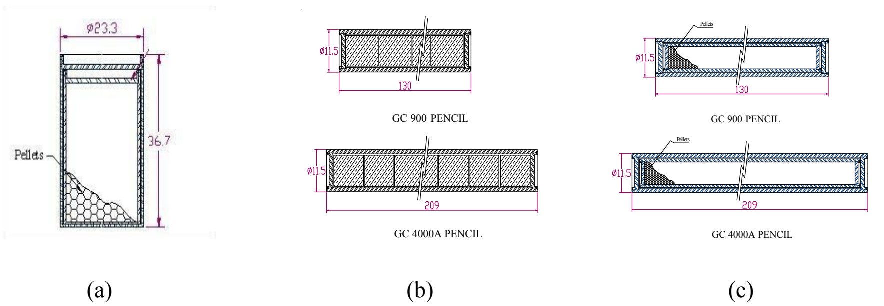

FIG. 1. Details of a teletherapy: capsule, gamma chamber pencil and gamma chamber pencils with the recovered gamma chamber pellets.

of the required ^{60}Co activity in the form of 1 mm (diameter) × 1 mm (thick) nickel coated, irradiated pellets with specific activity greater than 9.25 TBq/g (250 Ci/g) in standard stainless steel capsules, testing them for leak and surface contamination, measurement of activity/output and finally loading each source in a special shielding container for transferring the source into the teletherapy machine in the hospital. The sketch of teletherapy source is shown in Fig. 1.

When the source output reaches to less than 88.8 TBq (2400 Ci), treatment is not recommended as the time of treatment increases considerably. At this stage, fresh sources are loaded in the teletherapy machines and the decayed sources are returned to the BRIT supplier. These decayed sources are stored and recycled as per the following two methods.

2.1. Recycling of the decayed teletherapy sources

BRIT supplies ^{60}Co sources for their Gamma Chamber 900 and 4000 units for research purposes. The activity of these units is 111 TBq (3000 Ci) and 518 TBq (14 000 Ci) of ^{60}Co in 8–24 pencil sources in each unit. These sources are fabricated by double encapsulating the ^{60}Co slugs in the form of 6 mm (diameter) × 25 mm (long) stainless steel capsules. Fabrication of these sources requires very low specific activity slugs of ^{60}Co, with an activity in the range of 0.666–1.11 TBq/g (18–30 Ci/g) as needed. The gamma chamber source pencils are shown in Fig. 1(b). Selected decayed teletherapy sources are cut open in the hot cells and ^{60}Co pellets are recovered and used for the fabrication of the gamma chamber sources by doubly encapsulating them in stainless steel capsules. Figure 1(c) shows the gamma chamber pencils fabricated using the recovered ^{60}Co pellets from the decayed teletherapy sources. The advantages are the ^{60}Co produced can be used for another two to three half-lives and the disposal requirement reduces by 75% of the decayed teletherapy source activity. The risk of potential contamination during the cutting and recovery of the teletherapy sources and also in the fabrication of the gamma chamber sources has to be always kept in mind. Seventy decayed teletherapy sources with 3.7 PBq (100 kCi) have been used for the fabrication of 100 gamma chamber sources successfully without any significant difficulty.

2.2. Reuse of the decayed teletherapy sources

The decayed teletherapy sources are further encapsulated in the irradiator source pencils and are used in the industrial irradiators. Normally, inner pencils with slugs/pellets are used for the fabrication of the irradiator sources. Instead of slugs along with inner pencils, decayed teletherapy sources are used in the outer pencils. The decayed teletherapy sources are checked for leak and contamination before loading in the outer pencils. The sources so fabricated will have three encapsulations: two from the teletherapy sources; and one for the outer pencil, as compared with double encapsulation of the normal irradiator pencils. Dummy teletherapy sources are encapsulated in irradiator pencils and are tested as per ISO-9978/ISO-2999/AERB/SS-3, 2001, and as per ANSI-43.6. By using 300 decayed teletherapy sources with an activity of 14.8 PBq (400 kCi), 26 industrial irradiator pencils have so far been fabricated and supplied. The advantage of this method is that there is no recovery of ^{60}Co pellets, which eliminates the contamination problems in the hot cells. The dose output is similar to that of the standard W-91 pencils and the dose uniformity ratio is also not affected. The irradiator pencil (W-91 outer) and the pencil with the decayed teletherapy sources (W-91-Th) are shown in Figs 2 and 3.

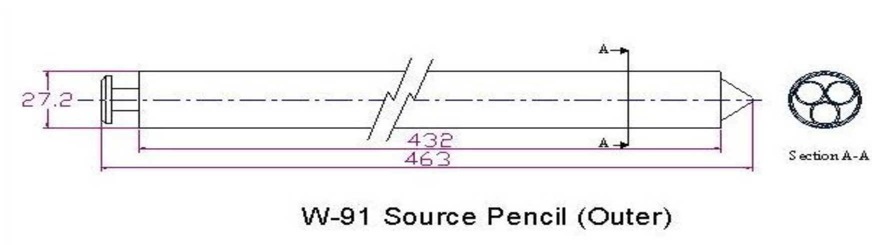

FIG. 2. Irradiator source pencil.

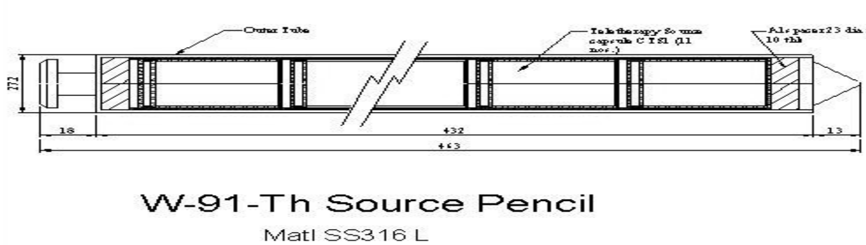

FIG. 3. W-91-Th source pencil with decayed teletherapy sources.

3. DECAYED ^{137}Cs TELETHERAPY SOURCES

Many hospitals had procured the ^{137}Cs teletherapy sources for the treatment of cancer before the cobalt availability. The activities of the sources were in the range of 44.4–51.8 TBq (1200–1400 Ci) and were doubly encapsulated. After the useful life of the sources, the source is to be sent for disposal to the manufacturer. Sending back to the international suppliers many times is not feasible for the hospitals. BRIT has recovered the source capsules from some of the teletherapy units in the hot cells and stored for further disposal. Caesium-137 is in the form of the CsCl powder or in the sintered pellets. One source, with 7.4 TBq (200 Ci), was cut open in the hot cell and the recovered ^{137}Cs activity was diluted and mixed with silica compound and other ingredients to convert to glass rods. The glass rod was cut into required number of pieces for the fabrication of the sources for the manual after loading brachytherapy applicators. Care has been taken for the contamination inside the hot cells during the recovery of ^{137}Cs [1, 2].

4. DECAYED NUCLEONIC GAUGING SOURCES USING ^{137}Cs

Nucleonic gauges using ^{60}Co and ^{137}Cs are used in many industries for the measurement of density and thickness, among other things. One of the users had 400 ^{137}Cs sources for disposal which were imported a long time ago. The activity of the sources varied, from 37 MBq (1 mCi) to 148 GBq (4 Ci). After the useful life of these sources, many were returned to BRIT for disposal, since they could not be sent to the original supplier. Many such sources were reused directly after checking the integrity of the source capsule or by further encapsulating them in a suitable stainless steel capsules. Necessary regulatory approvals were taken for the reuse. For another application, ten ^{137}Cs decayed sources — 74 GBq (2 Ci) each — were encapsulated. Two different size sources of 740 GBq (20 Ci) were fabricated and reused. Many sources in the range of 37 MBq (1 mCi) to 37 GBq (1 Ci) are reused after checking for the integrity of the sources.

5. DECAYED ^{192}Ir RADIOGRAPHY SOURCE DISCS

Gamma radiography using ^{192}Ir sealed source is a powerful tool in non-destructive testing technology. Iridium-192 activity used in the application varies from 740 GBq (20 Ci) to 3.7 TBq (100 Ci), depending on the model and capacity of the device. At present, 1200 iridium radiography sources with 1.48 PBq (40 kCi) are being used annually for the above application in India. Two to 12 irradiated natural iridium discs, with activity in the range of 148–518 GBq (4–14 Ci) are used in the production of the radiography sources. The natural iridium discs are normally irradiated for three to four months in a nuclear reactor to produce the required ^{192}Ir activity. When the source strength reduces to below 148 GBq (4 Ci), the decayed source is returned to BRIT and fresh source is taken for the radiography camera. In the first time irradiation, a maximum 5% of the ^{191}Ir atoms are converted to ^{192}Ir, and there is a scope to further irradiate these decayed ^{192}Ir discs. The decayed sources from the radiography devices were stored in flask for more than ten years. From the ten year old ^{192}Ir discs from the radiography source capsules, discs were recovered in the hot cells. The discs were once more irradiated to produce 148–444 GBq (4–12 Ci) and sources were fabricated for use in the radiography. It is proposed to recover and to irradiate for at least three cycles after recovering from the decayed ^{192}Ir sources. The requirement of the raw material, natural iridium reduces and the iridium is effectively used and is economical. Care is taken so that decayed iridium pellet is not cut during the recovery of the sources to avoid contamination of the hot cell.

6. CONCLUSION

Teletherapy sources are reused or recycled in the low specific activity applications such as gamma chamber units and irradiator sources for another 15–20 years after their first use and hence remain in the continuous control of the national regulatory agency. Decayed ^{192}Ir discs are recovered and further irradiated for the fabrication of the radiography sources. Decayed/disused ^{137}Cs sources are recycled for the other uses after receiving at BRIT. BRIT is actively pursuing the reuse and recycling of the sealed sources for the continuous control and effective utilization of the radioactivity produced which will reduce the radioactive waste for disposal. Recycling is an option which not only reduces waste to be disposed but also helps in economising the costs involved.

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CURRENT PRACTICES AND IMPLEMENTATION OF SAFETY AND SECURITY OF RADIOACTIVE SOURCES IN INDUSTRIAL RADIOGRAPHY IN THE PHILIPPINES

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Abstract

The paper aims to illustrate the current level of maturity on the compliance to the international regulatory requirements on safety and security of radioactive sources in the Philippines as perceived by the licensees themselves through the implementation of the Philippine Nuclear Research Institute (PNRI) as the regulatory body. The study showed that current practices and implementation of radiation safety in the use of radioactive sources in industrial radiography as perceive by the operators showed that out of the 38 questions, only five questions got an answer of 'No' (i.e. only 13.1% of the respondents are not compliant to the requirements — while 86.9% could be compliant). On the implementation of the security of radioactive sources, which was answered by senior managers, out of 14 respondents, 6, 1 and 5 respondents answered levels 3, 4 and 5, respectively. Therefore, the current security level of the licensees according to their perception showed the following: 50% at level 3, 8.33% at level 4 and 41.6% at level 5. The paper recommends that national regulatory requirements should be harmonized with the international standards and that continuing awareness and training programme should be carried out both for the operating organization and the regulators. The continued compliance to the Code of Conduct on the Safety and Security of Radioactive Sources and Guidance on the Import and Export of Radioactive Sources and the development and promotion of safety and security culture among radiographers and the regulators shall be one of the outcomes of the paper.

1. INTRODUCTION

In 2006, the Philippine Nuclear Research Institute (PNRI)[1], being the sole nuclear regulatory body in the State, adopted[2] and committed to have full implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and Guidance on the Import and Export of Radioactive Sources issued by the IAEA in 2004 [1]. In view of this, the PNRI ensured that the licensees involved in importing radioactive sources have the appropriate technical and administrative capability and resources needed for the management of the sources, among other provisions. Based on the data of the Nuclear Regulatory Division (NRD) — the regulatory arm of the PNRI, industrial radiography practices have the most number of radioactive sources under Category 2 (see table 1 in Ref. [2]) and the most number of radiological incidents, whether on safety or security matters [3]. One of the major regulatory activities fulfilled by the PNRI in compliance with the said commitment to the IAEA was the publication of the Code of PNRI Regulations (CPR) Part 26, Security of Radioactive Sources, in 2007 [4]. However, with the publication of the IAEA Nuclear Security Series No. 11, Security of Radioactive Sources [5], in 2009, and the Guidance on the Import and Export of Radioactive Sources [6], in 2012, the PNRI has to revise the said CPR in order to align with the newly published IAEA guidance. The revised CPR was aimed to be published in 2013.

This study, on the assessment of current practices and implementation of safety and security of radioactive sources used in industrial radiography in the Philippines, establishes a concrete baseline data on the said field of practices prior to the publication of the revised CPR Part 26. The research study was carried out using questionnaires that were developed based on IAEA Safety Standards Series No. SSG-11, Radiation Safety in Industrial Radiography [7], IAEA Nuclear Security Series No. 11 [5] and the World Institute for Nuclear Security (WINS) International Best Practice Guide on Security of Industrial Radiography Sources [8]. The questionnaires were distributed to all licensed radiography establishment that served as the respondents. The results showed the extent or profile on the use of radioactive sources in industrial radiography and on how the

[1] Republic Act 2067, as amended by RA 2380, also known as the Science Act of 1958, created the Philippine Atomic Energy Commission (PAEC) with a dual mandate to promote the peaceful applications of atomic energy and regulate the use of radioactive materials. Executive Order 128 of 30 January 1987 reorganized PAEC as the Philippine Nuclear Research Institute (PNRI), under the Department of Science and Technology (DOST).

[2] PNRI Administrative Order No. 02, Series of 2006, entitled Adoption of the Code of Conduct on the Safety and Security of Radioactive Sources and IAEA Guidance on the Import and Export of Radioactive Sources.

operators[3] implemented their safety and security measures as currently required by the PNRI. Prior to the IAEA publications relevant to safety and security of radioactive sources in industrial radiography [2, 9], in the early 2000s, the author had already published several research studies and technical reports based on practical experiences in the mid-1990s [10, 11]. Hence, the scope of this study was more focused on the security aspects of the industrial radiography practices. The study was in line with the objectives of the Regional Security of Radioactive Sources (RSRS) Project, financed by the Australian Nuclear Science and Technology Organisation (ANSTO) and the Global Threat Reduction Initiative (GTRI) [12].

1.1. Objectives of the study

The study provided a systematic approach in assessing current practices and implementation of the above mentioned fields. Specifically, this study provided data on the following:

(a) Current profile of the licensed industrial radiography operators, according to the following:
   — Number of radiography radioactive sources and radiography exposure devices in use indicating the manufacturer, and model numbers;
   — Number of radiation safety officers (RSOs), assistant RSOs (ASROs), radiographers and radiographer assistants;
   — Mode of practice, field or in-house/permanent radiography exposure room;
   — Location and type of permanent storage facility indicating the technical barriers.

(b) Current practices and implementation of radiation safety in the use of radioactive sources in industrial radiography as perceive by the operators in accordance with annex I of SSG-11.

(c) Current physical protection and security management implemented by the licensee in accordance with table 7 of IAEA Nuclear Security Series No. 11 [5], with modifications as in appendix C of Ref. [13].

(d) Current practices and implementation of the security of radioactive sources in industrial radiography as perceive by the operators in accordance with appendix A of International Best Practice Guide on Security of Industrial Radiography Sources [8].

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[3] The authorized entities should have the primary responsibility for implementing and maintaining security measures for radioactive sources in accordance with national requirements (see Ref. [5]).

(e) Level of organizational success on the implementation of the security of radioactive sources based on appendix B of International Best Practice Guide on Security of Industrial Radiography Sources [8].
(f) Feedback from the licensees on how to improve the current practices and implementation of the safety and security of radioactive sources in industrial radiography.

1.2. Significance of the study

The significance of the study is the attainment of some of the objectives of the ANSTO/GTRI RSRS Project. It serves as initial study or baseline data for a future study on the impact of the practices after three or more years of implementation of the regulatory requirements. Thus, it can be the basis for continual improvement in the regulatory system. It can serve as model study in the country and can be broaden into regional scope (i.e. South East Asia or the Asia-Pacific Region, and other regions of the world).

2. LEGAL AND REGULATORY FRAMEWORK

The legal framework in the field of radiation safety in the Philippines is divided between atomic energy facilities and materials regulated by the PNRI Department of Science and Technology (DOST) and electrically generated radiation apparatus regulated by the Center for Device Regulation, Radiation Health and Research (CDRRHR) under the Food and Drug Administration (FDA). The development of the legislative and statutory framework in each case is as follows.

2.1. Development and hierarchy of legislation for PNRI radiation regulation

(a) The Republic Act (RA) 2067, Science Act of 1958, as amended by RA 3509 established the Philippine Atomic Energy Commission (PAEC) on 13 June 1958.
(b) RA 5207, Atomic Energy Regulatory and Liability Act (1968), as amended by RA 3589 and by Presidential Decree (PD) 1484, established the authority of the PAEC and in particular its regulatory and licensing authority for atomic energy facilities (in part III) and atomic energy materials (part IV), and provisions specifying licensing requirements (part V); administration and review (part VI) and nuclear liability (part VII).

(c) PD 606, of 17 August 1982, created the PAEC as an independent and autonomous body and transferred it from the National Science Development Board to the Office of the President.
(d) Executive Order (EO) 128, of 30 January 1987, of the President, reorganized the Government and renamed the PAEC as the PNRI under the DOST. Department of Justice advice of 2 January 1989 stated that the PNRI had the same responsibilities and authority as the PAEC.
(e) The PNRI was rationalized in 2010, the Nuclear Regulations, Licensing and Safeguards Division (NRLSD) is now the NRD.

The above legislative framework governs the current functions of the PNRI, which include:

— To conduct nuclear research and development activities and transfer these to end users;
— To operate and maintain nuclear research reactors and other radiation facilities;
— To license and regulate nuclear facilities, other than those of the PNRI whose activities are exempt by Section 29 of RA 2067.

According to EO 128, the PNRI requires the NRLSD, now the NRD, to carry out licence review and evaluation, inspection and enforcement, standards development, radiological impact assessment and safeguards activities.

2.1.1. Development and hierarchy for Department of Health radiation regulation

(a) PD 480 (1974), entitled Creating a Radiation Health Office in the Department of Health, determined the functions separate to those for the PNRI (given by RA 5027) to regulate radiation emitting apparatus that does not contain atomic energy materials.
(b) PD 1372 amended PD 480 creating the Radiation Health Office in the Ministry of Health.
(c) EO 119 reorganized the Ministry of Health, its attached agencies and other purposes.
(d) EO 102 redirected the functions and operations of the Department of Health.
(e) RA 9711 Food and Drug Administration (FDA) Act of 2009, signed 18 August 2009, reorganized the Bureau of Health Devices and Technology into the CDRRHR under the FDA under the DOH.

However, at this point it could be noted that this study mainly deals with the gamma industrial radiography and will not touch on X ray industrial radiography, so that the succeeding discussions on the regulatory framework will be limited for the PNRI.

2.2. Responsibilities and functions of the PNRI as regulatory body

As described in the sections above, the two regulatory bodies of the PNRI and CDRRHR were established by the Government but with separate jurisdictions according to the radiation source or practice. The PNRI has the role of both promoting nuclear technology and services and regulating radiation and nuclear activities in the country. Additionally, the PNRI's own nuclear and radiation practices and activities are exempt from licensing under Section 29 of RA 5027. In 2004, however, the NRD was tasked to implement the PNRI Internal Regulatory Control Program through PNRI Office Order No. 2, series of 2004, whose purpose is to set up an internal authorization process for all PNRI nuclear and radiation facilities and laboratories. Thereby, all the said facilities are subject to regulatory compliance monitoring applying the CPR relevant to the practices.

The NRD is primarily responsible for implementing the PNRI's regulatory mandate of licensing and regulating the possession and use of nuclear and radioactive materials in accordance with RA 2067 and RA 5207 as duly amended, and for implementing nuclear safeguards in accordance with international commitments. These responsibilities include protecting public health and safety, protecting the environment, and protecting and safeguarding nuclear materials and radioactive materials in the interest of national security. The responsibilities of the NRD emanate from the functions of the PNRI as regulatory authority:

(a) Nuclear and radiation safety standards setting and rule making;
(b) Technical safety reviews and studies;
(c) Issuance of radioactive material licences;
(d) Regulatory compliance monitoring and inspection, investigation and enforcement;
(e) Evaluation of licensees' operating experience.

2.3. Relations between the regulatory body and the operator

With the establishment and implementation of the quality management system based on ISO 9001:2008 at the NRD since November 2008, its regulatory services became more customer focused. As part of compliance with its certification, the NRD has to conduct customer satisfaction measurements to ensure that the licensees are very satisfied with the delivery of regulatory services (e.g. availability of regulations and guidance materials, timeliness in the issuance of radioactive material licences and official inspection reports, and staff competency, among others).

In 2009, the PNRI Nuclear Safety Caravan was launched and brought to seven different regions of the country conducting regulatory conference and open forums with university students and licensees in the area and various stakeholders, which included radiation and non-radiation workers. The caravan was financed through the Grant-In-Aid Program of the DOST. The caravan is a public information and education campaign that sought to promote the open exchange of safety and security information among various stakeholders who are involved in the peaceful use of radioactive materials in the country. Apart from the awareness seminars, demonstration on the use of modern radiation detectors and lectures to teachers and students were also conducted. The caravan was carried out in another three different regions in 2010.

Another form of regulatory information dissemination is through the issuance of the NRD Regulatory Information Bulletin on urgent safety and security related issues that need to be brought to the attention of the licensees and other stakeholders for compliance with response or for reference purposes only.

2.4. Other activities of the regulatory body

The quality management system of the NRD was certified under ISO 9001:2008 in November 2008. The certification is valid for three years. The NRD has to pass the yearly surveillance audit of the certifying body to maintain its certification. It is now on its second cycle and this year the certification will be for the whole PNRI. In view hereof, all NRD activities are performed in accordance with formal written procedures and work instructions.

Some PNRI regulatory activities that are relevant to ensure the continuous safety and security of radioactive materials are the issuance of ‘certificate of release’ and ‘authority to transport’ for the Bureau of Customs to facilitate the release of imported radioactive materials and to facilitate the transport of the radioactive materials for reference to the Philippine National Police, the Philippine Port Authority and Airlines Cargo, among others, respectively. The submission of the annual report on the use of radioactive materials is within the reporting year. In addition, an amended licence is to be acquired before importing new radiography exposure devices, and notification from an importing country is received on the incoming radiography sources and camera, if there is one. The end-of-life cycle of the radiography sources can be acquired from the electronic database of LRES but the said database has yet to be improved.

3. RESEARCH METHODOLOGY

3.1. Research design

The study aims to assess and understand the broader discussion about the perception of industrial radiography licensees' compliance to the security and safety requirements of PNRI regulations in their field of operations, in particular on its maturity level. Survey questionnaire and key informant interviews are the main methodologies employed. The unit of analysis was carried out on the industrial radiography licensees and their perceptions. In order to have a better population, the study covered all the licensees and did not include the licensees with 'for storage only' authorization due to inadequate staff that needs to answer the questionnaires. The three sets of questionnaire was with multiple items using 'Yes' or 'No' answer. The higher score for 'Yes' indicates the higher extent of compliance to the requirements of the practices and the number of 'No' scores indicates less compliance to the regulatory requirements of the practices. The development of the final questionnaire was pre-tested by filling out the draft questionnaire, and a non-structured interview was carried to fill in the weaknesses of the questionnaire. The questionnaire was piloted by three PNRI staff who are involved in the conduct of industrial radiography as part of the practical exercise in the conduct of certification training at the PNRI. The filled out piloted questionnaires were excluded in the final study. The information was triangulated by reviewing the results of the PNRI Official Inspection Reports for 2009–2011 and calls to some respondents to validate their answers and the applicable codes of PNRI regulations [14]. A focus group discussion[4] was planned for triangulation of the data but did not forgo due to some time constraints, the same with the attendance during the regulatory conference[5] on security of radioactive materials, which was held while the author was out of the country.

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[4] The focus group discussion was to be carried out with the board of directors of the Philippine Society for Nondestructive Testing who are also in management positions or RSOs of licensed radiography companies.

[5] Regulatory Conference on the Revision of CPR Part 26 Security of Radioactive Sources, held at the PNRI on 27 June 2013

3.2. The population and sample

According to the designed milestone or timetable of the study, data gathering and analysis has an allotted duration of almost a month only. The samples of the study were drawn from the list of licensed users in the database[6] of Licensing, Review and Evaluation Section (LRES) of the NRD. All licensed users with a valid licence to acquire, possess and use radioactive materials were drawn as respondents, except for the National Training Center (NTC) of the PNRI, which served as the pre-test respondents of the questionnaires.

After determining the current validity of the licence of the organizations listed in the LRES database, 22 questionnaires were sent out to the licensees — of which only 12 questionnaires were properly filled out and returned. After some validation of the answers through telephone call of the respondents, all the returned questionnaires were considered valid for the analysis of the data.

4. RESULTS AND DISCUSSIONS

This section presents the empirical data and the analysis and interpretation of this study. On the respondents' profile, the companies' number of staff ranges from 9 to 308 employees, while there are 36 RSOs, 26 ARSOs, 204 radiographers and 117 radiographer assistants. It is a mandatory regulatory requirement to have at least one RSO and one ARSO. The ARSO is to act in the absence of the RSO. The work experience of the respondents, such as senior managers, RSOs and radiographers, ranges from 5 to 31 years. Most of the radiography companies, if not all, are corporate member of the Philippine Society for Nondestructive Testing. From their characteristics, the respondents are therefore highly qualified to give their objective perception and feedback.

[6] The electronic database being maintained by the LRES contains licensee data such as: list of equipment with the manufacturer name model and serial number; list of authorized radioactive materials with name of manufacturer, model and serial number and the corresponding maximum amount of activity that can be possessed at any one time; authorized place of use or permanent storage; name of RSO, ARSO and personnel authorized to handle and use the radioactive materials; special conditions; business address; and contact numbers.

4.1. National profile of industrial gamma radiography

In the Philippines, there are currently 25 industrial radiography entities that are licensed/authorized by the PNRI, 24 private companies and one government owned by the NTC of the PNRI. Of the 25, only 2 are without a valid licence (i.e. one that expired several months ago). To classify the said companies into their size according to capital investment or number of personnel, there are 12 large companies, 7 medium and 5 small, with none at the micro size. The sizes of the companies will have a relationship in complying with the regulatory requirements on safety and security that requires financial resources. For additional data, see Figs 1–5.

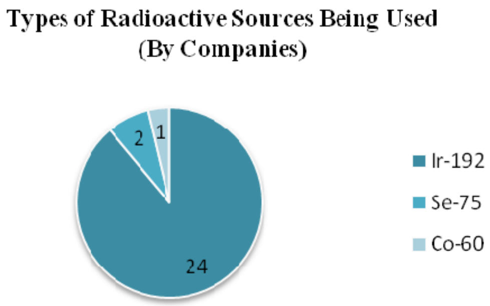

FIG. 1. Types of radioactive source.

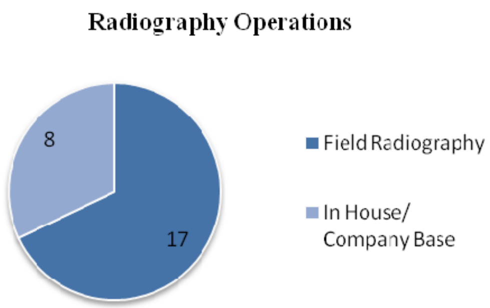

FIG. 2. Mode of operations.

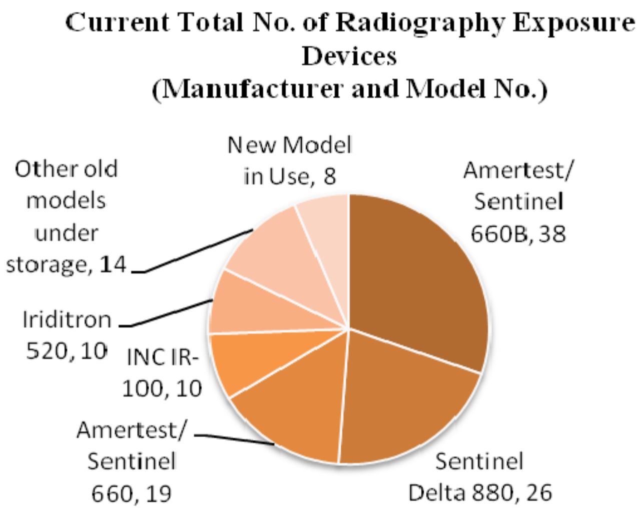

FIG. 3. Number of radiography radioactive sources and radiography exposure devices in use, indicating the manufacturer and model number.

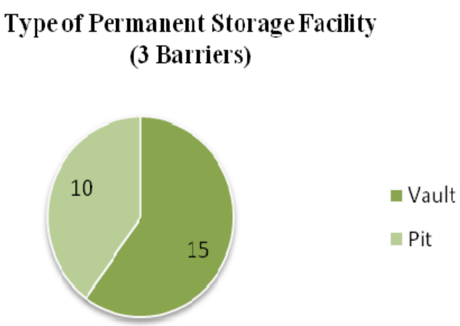

FIG. 4. Type of permanent storage facility.

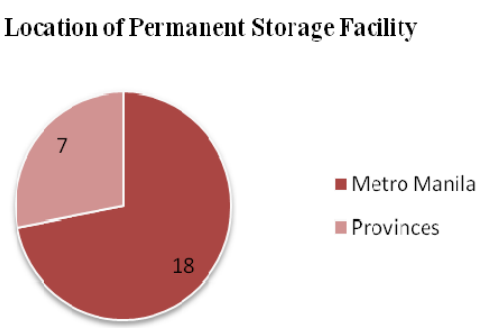

FIG. 5. Location of permanent storage.

4.2. Results

Table 1 shows the 'No' answers with regard to the current practices and implementation of radiation safety in the use of radioactive sources in industrial radiography as perceived by the operators in accordance with annex I of SSG-11 [7]. The 'No' answers result shows that out of the 38 questions on safety as indicated in annex I of SSG-11 [7] only 5 questions got an answer of 'No' (i.e. only 13.1% of the respondents is not compliant to the requirements — while 86.9% could be compliant). The highest question with 'No' answer is "Female employee in the operating organization, being advised of the necessity and importance of informing her manager if she were to become pregnant" for getting four 'No' answers (see Table 1). It shows that this safety requirement is the least complied with by the respondents. The next safety requirements that should be looked into are "Dose investigation level of 2 mSv/year set by the management. This value serves as useful management tool and is included in the local rules" and "Radiographers undergo annual health reviews with a doctor approved by the regulatory body. Radiographers are entitled to see the results of their health reviews" — both getting three 'No' answers. The questionnaire was answered by the NDT supervisor, RSO or ARSO.

TABLE 1. 'NO' ANSWERS ON SAFETY BASED ON SSG-11

No. of respondents	Questions
4	Female employee in the operating organization, being advised of the necessity and importance of informing her manager if she were to become pregnant.
3	Dose investigation level of 2 mSv/year set by the management. This value serves as useful management tool and is included in the local rules.
3	Radiographers undergo annual health reviews with a doctor approved by the regulatory body. Radiographers are entitled to see the results of their health reviews.
2	Fire prevention measures.
1	Written procedure to minimize the risk of human error.

Table 2 shows the ‘No’ answers with regard to the current physical protection and security management implemented by the licensee in accordance with table 7 of IAEA Nuclear Security Series No. 11 [5], with modifications as in appendix C of Ref. [13]. The ‘No’ answers result shows that out of the 13 questions on security as indicated in table 7 of IAEA Nuclear Security Series No. 11 [5], with modifications as in appendix C of Ref. [13], only 3 questions got an answer of ‘No’. The highest was ‘Conduct remote monitoring of CCTV’, which received four ‘No’ answers. The next security requirement that should be looked into is ‘Tamper detection equipment’, which received three ‘No’ answers. The last with one ‘No’ answer was all the requirements for safety management. The questionnaire was answered by a radiographer or radiographer assistants.

Table 3 shows the ‘No’ answers with regard to the current practices and implementation of the security of radioactive sources in industrial radiography as perceive by the operators in accordance with appendix A of International Best Practice Guide on Security of Industrial Radiography Sources [8] showed the ‘No’ answers at Table 3. The ‘No’ answers result showed that out of the 24 questions on security as indicated in appendix A of International Best Practice Guide on Security of Industrial Radiography Sources [8], ten questions got an answer of ‘No’ and the highest was “Aware if there has been an evaluation of the threats to radioactive sources and particular those used for your sources”, which received four ‘No’ answers. The next security requirements that should be looked into is “Receive written instruction on the event of a security incidents”, which received three ‘No’ answers. The other ‘No’ answers, each with two respondents, are: “Approved standards or policies for the security of sources during the various operations involving them”; “Periodic exercise your security management and procedures”; and “Have security response arrangements in place”. The others as listed in Table 3 each received a ‘No’ answer. The questionnaire was answered by senior managers, NDT supervisors, RSOs or ARSOs, and radiographer or radiographer assistants.

TABLE 2. ‘NO’ ANSWERS ON SECURITY BASED ON IAEA NUCLEAR SECURITY SERIES NO. 11

No. of respondents	Questions
4	Conduct remote monitoring of CCTV
3	Tamper detection equipment
1	Safety management

TABLE 3. ‘NO’ ANSWERS ON SECURITY BASED ON INTERNATIONAL BEST PRACTICE GUIDE ON SECURITY OF INDUSTRIAL RADIOGRAPHY SOURCES

No. of respondents	Questions
4	Aware if there has been an evaluation of the threats to radioactive sources and particular those used for your sources
3	Receive written instruction on the event of a security incidents
2	Approved standards or policies for the security of sources during the various operations involving them
2	Periodic exercise your security management and procedures
2	Have security response arrangements in place
0	Regular training for individual involved in the security of industrial radiography sources
0	Approved a training programme for individuals involved in the security of industrial radiograph sources
0	Conduct periodic meetings with staff on security threats or requirements
0	Have security procedures for protecting sources at premises
0	Specific security features and procedures for vehicles transporting sources

4.2.1. Security maturity level as perceived by the respondents

With regard to the level of organizational success on the implementation of the security of radioactive sources based on appendix B of International Best Practice Guide on Security of Industrial Radiography Sources [8], which was answered by the president, vice-resident or general manager, out of 14 respondents, 6, 1 and 5 respondents answered levels 3, 4 and 5, respectively (see Table 4). Therefore, the current security level of the licensee according to their perception showed the following: 50% at level 3; 8.33% at level 4; and 41.6% at level 5.

TABLE 4. DEFINING DIFFERENT LEVELS OF ORGANIZATIONAL SUCCESS

Level		Characteristics
1	(a)	The organization does not have a security plan and is not clear who has the responsibility for assuring the security of the industrial radiography sources.
	(b)	Sources are routinely left unattended, particularly during transport.
	(c)	There is no vetting (background check) of personnel who handle the industrial radiography sources and a two person rule is not generally applied.
	(d)	There is no response plan in the event of a security incident involving the sources and, consequently, there is no response exercise.
	(e)	There is little training on security awareness or procedures for individuals responsible for the sources or working with them.
2	(a)	Management is aware that it is responsible for assuring the security of industrial radiography sources.
	(b)	Sources are locked most of the time but occasionally, when inconvenient to do so, they may go unattended.
	(c)	There is no vetting (background check) of personnel who handle the industrial radiography sources. The two person rule is applied where convenient.
	(d)	There is little concern about incident planning, but contacts have been made with local law enforcement authorities.
	(e)	Some security awareness and procedures training is conducted but not on a structured basis.
3	(a)	Management is aware that it is responsible for securing the industrial radiography sources.
	(b)	The organization has operational procedures which delineates the management accountability for security.
	(c)	A vetting (background check) programme has been developed but not fully implemented because of slow or inadequate response.
	(d)	A two person rule for access to the sources at the fixed location but is not always applied at other location and in transport.
	(e)	Contacts have been made to the local law enforcement and authorities about the possible need for support in an emergency. Response exercises have not been conducted.
	(f)	Security awareness training is provided to individuals responsible for the sources in a structured manner.

TABLE 4. DEFINING DIFFERENT LEVELS OF ORGANIZATIONAL SUCCESS (cont.)

Level		Characteristics
4	(a)	Management is aware of possible threats to the sources and has a grasps of the possible consequences resulting from the malicious act.
	(b)	The organization has a security plan which reflects the authority and accountability of security management.
	(c)	Vetting (background check) is in place which includes reference checks allowed by company policies and national laws.
	(d)	A two person rule policy is in place but is not always fully implemented in practice.
	(e)	Contacts are made to the local law enforcement and authorities to make them aware of the sources and support needed in an emergency. Response exercises are conducted occasionally.
	(f)	A training programme is conducted to provide security awareness to individuals responsible for the sources or working for them. The competency of radiographers for their responsibilities is considered.
5	(a)	Management is aware of the credible threats to the sources and knowledgeable of the possible consequences resulting from the malicious act.
	(b)	The organization has a detailed security plan which clearly delineates the authority and accountability of security management.
	(c)	An extensive vetting (background check) programme is in place which includes reference checks, trustworthiness determinations, as allowed by company policies and national laws.
	(d)	A two person rule for access to sources at the base, in transport and at the site has been implemented and operates effectively.
	(e)	Contacts are made to the local law enforcement and authorities to make them aware of the sources and support needed in an emergency. Response exercises are conducted occasionally.
	(f)	A training programme is conducted to provide security awareness to individuals responsible for the sources or working for them. The competency of radiographers for their responsibilities is considered.

Source: See appendix B of International Best Practice Guide on Security of Industrial Radiography Sources [8].

4.2.2. Feedback from the licensees

The following are the summarized licensees/respondent’s feedback on how to improve the current practices and implementation of the safety and security of radioactive sources in industrial radiography:

— To undergo regular/yearly training on safety and security of radioactive sources with presentation of case studies;
— To have a regular meeting/forum of all safety and security officers to be facilitated by the PNRI, covering benchmarking and brainstorming for continual improvement;
— Suggestion that the personnel involve should receive a regular newsletter pertaining to updates and basic information on regulatory matters;
— Tool box meetings on safety and security, every day before the start of work;
— The PNRI always needs to conduct a surprise or unannounced inspection in the field to make sure that only qualified and trained radiographers are using the radiography exposure devices.

5. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary of findings

This study has addressed the central question on how and to what extent has the licence complied with the regulatory requirements on the safety and security of radioactive materials — as perceived by the licensees themselves. This was done by outlining the views on implementation using the questionnaires developed by international organizations and others that are personally developed with some modifications. The results showed that, in general, the industrial radiography licensees have perceived a relatively successful implementation of their safety and security as aligned with the international regulatory requirements and guidance as enumerated in the references.

The licensees' perception shows that their implementation and compliance to the regulatory requirement have gone a higher maturity level specially on safety as indicated by the results. However, this is contrary to the results of the PNRI Official Inspection Reports for 2009–2011, which showed an average of two to three non-compliances every regular/announced inspections and four to seven non-compliances on unannounced inspections. As per verification with the Inspection and Enforcement Section of the NRD, it showed that they are not fully enforcing the security requirements in industrial radiography. The high number of non-compliances during the conduct of unannounced inspection is indicative of a poor or degrading safety and security culture.

The 5 questions which were answered 'No' by the licensee out of 38 questions under safety, as per verification with the CPR Part 11 Licenses for Industrial Radiography and Radiation Safety Requirements for Radiographic

Operations showed that none of the items and is stipulated in the said direct regulations applicable for industrial radiography.

5.2. Conclusions

Due to the relatively new nature of the international commitments, standards and requirements applying to radioactive source security (e.g. Refs [5, 8]), effort is still required to understand them and to obtain experience with their application, including feedback from operators, regulators and international partners [15]. This study has utilized the said sets of guidance to assess and to determine its current implementation in the country, and the results could be used to improve and strengthen the legal and regulatory infrastructure of the PNRI through a more compliant and participative licensees.

The PNRI, with the NRD as the regulatory arm, needs to improve their legal framework towards being effectively independent. They have a well established efficient and effective regulatory framework that could be the results of the maintenance of their quality management system having been certified to ISO 9001:2008 for five years now.

The latest revision of CPR Part 11 Licenses for Industrial Radiography and Radiation Safety Requirements for Radiographic Operations, issued in February 2010, the ongoing revision of CPR Part 26 Security of Radioactive Sources — the first version published in 2007, and the development of CPR Part 27 Security in the Transport of Radioactive Materials are indications that the PNRI is at a par with other States in the implementation of international standards and regulations on the safety and security of radioactive sources in industrial radiography. However, it has to be continuously harmonized with the international standards.

5.3. Recommendations

It is highly recommended that the PNRI continuously participates with other State programmes or has a bilateral agreement, especially with the RSRS Project of ANSTO/United States Department of Energy (DOE) and GTRI of the DOE. Reference [13] discusses how the workshop and its outcomes affirm the importance of a cooperative approach within the region and also with the international programmes. It demonstrates that successful networking requires regular, purposeful contact between partner agencies and individuals, and that this is a prerequisite to obtaining shared commitment and objectives for radioactive source security.

Even India, a State with an established legal and regulatory infrastructure and known for their highly educated and competent regulatory staff, has indicated the need for procedures to be devised for maintaining strict control in respect to safe and secure storage of radioactive material, especially when the sources are used in public domain (e.g. industrial radiography) [16]. The conduct of regular training and awareness programmes for users, maintenance staff and administrators, among others as required, were also highlighted.

Furthermore, the results can also be used in future study (i.e. a study on impact evaluation/before and after) that could be performed three years after the full implementation of regulatory requirements on the safety and security of radioactive sources in industrial radiography. In addition to developing and promoting safety and security culture programme among NRD staff and stakeholder, the right way is leading by example.

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LONG TERM SAFE AND SECURE MANAGEMENT OF, AND FUNDING FOR, DISUSED SOURCES, INCLUDING LEGACY SOURCES

(Session 6)

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RAPPORTEURS' SUMMARY

Session 6: Long Term Safe and Secure Management of, and Funding for, Disused Sources, Including Legacy Sources

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Session 6 included several national experiences in the long term management of the radioactive sources. The implementation of international technical assistance projects and the IAEA approach to address the issue of disused sealed radioactive sources (DSRSs) in States were also discussed. The session highlighted the need for enhanced harmonization in the end-of-life management of radioactive sources and for an increase of international exchanges on this topic.

A number of States presented their mechanisms for safe and secure conditioning and storage of low activity sources. In addition, the IAEA's assistance to States in the management of DSRSs was discussed, including the factors used to prioritize activities, including national inventories, the safety and security situation in the county and the availability of funds. A variety of options (repatriation, in country storage and recycling) are considered and the solution is specific to the State and not 'one size fits all'.

An extensive discussion of borehole disposal was also had, with a view to clarifying its intent. Various participants expressed views on this subject, and it was noted that when it was conceived, it was with the understanding that there would be no future intent to retrieve the source. It was also expressed that the borehole could be used by certain States, but that it should not be seen as a universal solution.

A number of participants expressed the need for additional guidance on the safe and secure management of disused sources, and it was noted that a link between the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) and the Code of Conduct is needed to address this gap. The issue of financial guarantees and how to implement them in a harmonized manner also raised also many questions.

The following recommendations were made:

(a) The management of sources at the end of their useful lives needs additional guidance and harmonization at the international level, in particular concerning the development of a national policy (including the establishment of interim storages and disposals), the organization of the return to suppliers, financial provisions (i.e. to cover the cost of waste management), and the interface with transport and waste regulations. This gap could be addressed in two complementary ways: in the middle or longer term, through the development of a convention pertinent to the management of the safety and security of sources. In the shorter term, it could be addressed through the development of additional guidance linked to the Code of Conduct. It was suggested that the IAEA could consider taking further actions on these issues, for instance organizing a dedicated meeting to explore both options: a Convention or supplementary guidance.

(b) As part of the baseline strategy of return of sources to the suppliers, States licensing suppliers are encouraged to strengthen their cooperation and to establish safety and security criteria for the export of radioactive sources and to commit to keeping records of their supply for a certain period of time.

(c) States are strongly encouraged to ratify the Joint Convention. The IAEA is further encouraged to continue efforts to promote the ratification of the Joint Convention by all States.

The main conclusions from Session 6 were:

(a) Return to the supplier of disused Category 1 and 2 radioactive sources should remain the baseline management option for the end of life of these sources.

(b) The implementation of the principle of return of disused sources to the supplier requires the establishment of safe and secure national interim storage within the framework of a national policy for the management of sources.

(c) Return to a supplier requires funding, for instance to cover the prior packaging and for the transport of the disused source.

(d) Identification of a supplier for the return of sources can be difficult in some cases and there is a need for a backup option. Disposal capabilities should be developed for every region, in order to avoid interim storage becoming de facto long term disposals.

(e) Transport, radiation, waste safety and security regulations have significant interfaces for sources and it remains a significant challenge to ensure they are adequately bridged.

IAEA-CN-204/226

URBAN RADIOACTIVE WASTE REPOSITORIES IN CHINA

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Abstract

In order to strengthen the storage and management of radioactive waste and disused radioactive sources, the Chinese Government decided in 2005 to construct urban radioactive waste repositories to achieve “one province, one repository”. This project constructed and renovated 31 urban repositories as well as one national repository. Through several years of unremitting efforts, all the repositories have been completed and put into use. The paper introduces the situation of this project and details information by taking the Jiangsu repository as an example, and analyses challenges and problems of disused sources in recovery, conditioning and disposal in China.

1. OVERALL SITUATION OF THE REPOSITORY PROJECT

Along with the rapid economic development in China, nuclear technology utilization industry is also expanding rapidly. However, the increased radioactive waste brings great pressure on radiation safety and restricts the development of the industry. In order to properly solve the problem the former State Environmental Protection Administration, the predecessor of the Ministry of Environmental Protection (MEP), in accordance with the National Development and Reform Commission, launched a project of construction radioactive waste repositories in 2004. The investment of this project is ¥ 413.19 million, including the central government investment of ¥ 362.15 million and the provincial local government matching funds of ¥ 51.04 million.

The last repository — a Guangxi urban radioactive waste repository — passed the environmental protection acceptance in December 2012. This demonstrates that the China urban radioactive waste repositories construction project has been successfully completed. This project achieved the “one province, one repository” objective, which means each province has an urban radioactive waste repository. In total, the repositories project constructed 18 400 m^3 provincial storage capacity for 31 provinces and 2600 m^3 national storage capacity. These repositories greatly improved the capacity and security level of radioactive waste and disused sources temporary storage in China.

At the same time of the repositories construction, the Chinese government also worked on dealing with the legacy sources. The entire inventory of old provincial repositories in 29 provinces was cleaned up and sent to the national repository. In this work, 72 433 disused sources, with a total activity of 1.118×10^{16} Bq were dealt with and formed 1609.3 m^3 radioactive waste.

2. INTRODUCTION OF URBAN RADIOACTIVE WASTE REPOSITORY

The Chinese Government held a public bid for the design scheme of urban repositories. In the end, the Fourth Research and Design Institute of the China National Nuclear Corporation won the bid, and as a result, all of the repositories use its designs and have common, basic standard designs:

— Semi-underground type;
— Partitioned storage for sources and waste;
— Accessory laboratory;
— Unified safety and security systems.

The Jiangsu repository is taken as an example to introduce the structure and ancillary equipment of repositories. In May 2008, the Jiangsu repository construction was launched, and after the environmental protection acceptance, it got received a radiation safety license and was put into operation in 2010. This repository, which is a semi-underground repository, like other provincial repositories, occupies a 100 mu site (1 mu = 666.67 m^2) and has 1200 m^3 storage capacity, with 40 pits. Each pit is 7.5 m long, 3 m wide and 2.5 m high, and the depth of underground part and the height of the above ground part are 1.7 m and 0.8 m, respectively. The pit is covered by slabs 0.3 m thick and 1.8 t heavy. The structure of the pit is shown in Fig. 1.

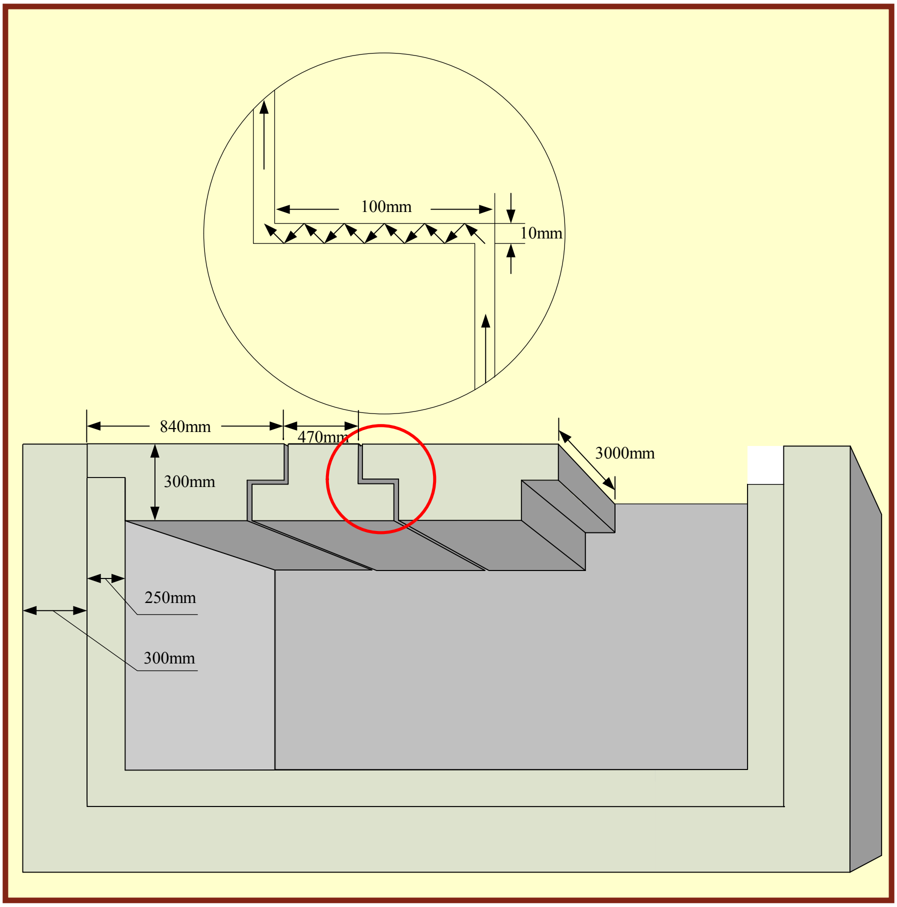

FIG. 1. Structure of the pit.

The cover slabs are operated by an electric crane (see Fig. 2). The Jiangsu repository is equipped with a variable frequency and speed crane with 3 t capacity, which consists of automatic crawler and rigid telescopic mechanism and can be controlled via remote operation. The high positioning accuracy of this crane (which is in 6 mm) allows the slabs to be operated precisely.

The storage of disused sources and radioactive waste are partitioned in the Jiangsu repository. There are different areas to store various sources and radioactive waste.

FIG. 2. Crane and crawler.

Before the sources or waste are put into the pits, they are stored in storage containers which are made of boron steels with very good resistance to radiation, impact, water and corrosion. There are two kinds of storage containers, and the main difference between them is their sizes (see Fig. 3). The size of the containers for waste is 90 cm in height, 55 cm in diameter and 200 L in volume, while the size of the containers for sources is 48 cm in height, 41 cm in diameter and 50 L in volume.

The Jiangsu repository has safety and security systems according to the requirement of the standard design. These systems consist of:

— Intrusion alarm system;
— Video surveillance system;
— Access control system;
— Fire alarm system
— Dose line monitoring system.

The intrusion alarm system is composed of electronic perimeter fence, repository surrounding infrared detectors, door sensors at logistics and exhaust engine rooms, infrared microwave detectors in repository, and other equipment as shown in Fig. 4. This system ensures any illegal intrusion can be detected immediately.

The video surveillance system includes ten sets of outdoor camera surrounding the repository, indoor camera in front of every door of the repository, and two sets of fixed focus camera at two opposite corners of the repository. This system can effectively monitor the repository.

The access control system is composed of door sensors, power locks and fingerprint readers, which are set for personnel access. If the authentication fails or the device is destroyed, the system will alarm.

FIG. 3. Two kinds of containers.

FIG. 4. Electronic perimeter fence and infrared detector.

The fire alarm system has smoke alarms, sprinkler systems and manual alarms in public positions.

The dose line monitoring system includes eight indoor fixed probes and three high pressure ionization chambers. This system can continuously monitor the radiation dose both inside and outside of the repository.

The Jiangsu repository has two specialized vehicles which are specially modified by special automobile works to be adapted for the transport of disused sources. One is uniformly allocated by MEP (see Fig. 5) and the other is purchased by the local government. The modifications in these vehicles focus on functions of shielding and hoisting. These vehicles are equipped with GPS, so that they can be monitored and tracked easily. These vehicles also equipped motion alarm and overspeed alarm devices and radiation dose monitoring instruments. These devices are used to ensure the security and safety of these vehicles.

The Jiangsu repository also has a decontamination site, shower room, office rooms and other auxiliary buildings. All staff are provided with protective clothing, safety glasses, gloves and other protective equipment as well as the radiation dose monitoring equipment such as portable spectrometers.

3. CHALLENGES

Urban waste repositories construction project greatly enhance Chinese storage capacity on disused sources and radioactive waste, for example, the Jiangsu repository can meet the storage needs of Jiangsu province for the next 30 years. This project also improved the level of disused sources and radioactive waste security in nationwide. However, China still faces two challenges in the area of disused sources conditioning and disposal.

FIG. 5. Vehicle equipped by the MEP.

The first challenge is lack of recovery and storage funds. Currently, the owners are only in charge of the storage costs in China, while conditioning and disposal costs still need additional financing.

The other is the technology of conditioning and disposal of sources are still immature. The disused sources in national repository can only be stored in the next few years. Researches on conditioning, disposal and recycling have been rationally carrying out in China for a few years. The MEP and the Ministry of Science and Technology have jointly set up related topics, and the Institute for Radiation Protection of China and other research institutes have studied and made certain progress. China will definitely continue to promote researches on disposal and recycling of radioactive sources, and endeavour to realize the recycle of high recycle value radioactive sources, such as ^{241}Am, and dispose the low recycle value radioactive sources.

IAEA-CN-204/183

FRENCH EXPERIENCE OF DSRS MANAGEMENT

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Abstract

Sealed radioactive sources require a safe and secure management 'from cradle to grave'. The risk of loss of control is exacerbated when the source is no longer used: disused sealed radioactive sources (DSRSs) require a safe and secure storage until their elimination. Each individual DSRS should either be recycled or managed as radioactive waste, and a way to a disposal should be found.

1. INTRODUCTION

Sealed radioactive sources require a safe and secure management 'from cradle to grave'. The risk of loss of control is exacerbated when the source is no longer used. For this reason, the paper is focused on the management of disused sealed radioactive sources (DSRSs).

In a first step, DSRSs have to be collected in a safe and secure storage. Then, their elimination has to be organized. Elimination of a DSRS can only be realized by two potential processes: recycling or management as waste.

In France, the planning act of 28 June 2006, concerning the Sustainable Management of Radioactive Materials and Waste, entrust to the government to develop a National Plan Management for Radioactive Materials and Waste (PNGMDR, Plan national de gestion des matières et déchets radioactifs). The National Radioactive Waste Management Agency (Andra, Agence nationale pour la gestion des déchets radioactifs), the French Alternative Energies and Atomic Energy Commission (CEA, Commissariat à l'énergie atomique et aux énergies alternatives) and a specific waste management group in the framework of the PNGMDR are in the process of creating the necessary disposal solutions for any type of DSRS.

2. COLLECTING DISUSED SEALED RADIOACTIVE SOURCES

French regulation requires that any DSRS has to be collected by the supplier of the source.

In the present situation with no available waste solution, the supplier can:

- Store the source;
- Return the source to its own supplier, who is in most cases the producer;
- Search for a recycling opportunity.

Return to supplier or producer as well as recycling may require exporting the source.

3. THE PNGMDR AND RADIOACTIVE WASTE MANAGEMENT IN FRANCE

The main PNGMDR objectives are as follows:

- To establish a clear definition of the waste categories to be considered as radioactive;
- To seek long term management solutions for every category of radioactive waste being produced;
- To take due account of public concerns about the future of radioactive waste.

The various types of radioactive wastes are classified according to the half-lives and radioactivity levels of the main radionuclides they contain. With regard to half-lives, they are divided into very short (less than 100 days), short (between 100 days and 31 years) and long (over 31 years).

In France, there are six major waste categories depending on their radioactive content (activity level and half-life) as follows:

- High level waste consisting mainly of vitrified waste as a result of nuclear fuel reprocessing, in the order of billions of Bq/g;
- Intermediate level long lived waste consisting mainly of cemented waste packages, in the order of millions of Bq/g;
- Low level long lived waste consisting mainly of graphite and radium waste, in the order of 100 000 Bq/g;
- Low level and intermediate level short lived waste resulting mainly from the operation and dismantling of nuclear power plants, fuel cycle facilities and research facilities;

— Very low level waste having the same origin, with activity levels below 100 Bq/g;
— Very short lived waste resulting mainly from medical uses, which can be managed by radioactive decay, and are not considered radioactive after decay (this option is not available for DSRSs).

Table 1 presents the global national strategy for the management of radioactive waste.

TABLE 1. MAIN LONG TERM MANAGEMENT SOLUTIONS FOR EACH WASTE CATEGORY; SHALLOW DISPOSAL AND GEOLOGICAL DISPOSAL ARE UNDER STUDY

Activity	Short half-life (≤31 years)	Long half-life (>31 years)
Very low level	Surface disposal (CSTFA)	Surface disposal (CSTFA)
Low level	Surface disposal (CSFMA) except for tritiated waste	Dedicated shallow disposal (FAVL)
Intermediate level	Surface disposal (CSFMA) except for tritiated waste	Geological disposal (MAVL)
High level	Geological disposal (HAVL)	Geological disposal (HAVL)

4. PNGMDR AND DSRS MANAGEMENT IN FRANCE: ANDRA CRITERIA FOR DSRS DISPOSAL ACCEPTANCE

DSRSs have some specific characteristics which have to be considered when the decision is taken to manage them as radioactive waste: attractiveness and concentration of activity. The consequence is that DSRS waste packages may need a specific characterization process and include radiological protection such as lead, depleted uranium and cement.

Very high activity DSRSs (mainly Categories 1 and 2, see Ref. [1]) may remain dangerous after a long duration of storage or disposal. Decay from 1 TBq to 1 Bq needs 40 half-lives: Table 2 provides typical examples for frequent isotopes.

TABLE 2. DECAY TIME FROM 1 TBQ TO 1 BQ FOR SOME TYPICAL HIGH ACTIVITY DSRSS

Isotope	Decay time (years)
Co-57	30
Co-60	200
Cs-137, Sr-90	1 200
Pu-238	3 500
Am-241	18 000
Ra-226	64 000

Andra has established criteria or draft criteria for each existing or planned disposal. CSTFA surface disposal should receive all DSRSs completely decayed after 30 years: detailed criteria are in preparation and will include all DSRS with a half-life of less than one year.

CSFMA surface disposal can receive all DSRSs which present no danger after 300 years: detailed criteria are available and include all DSRSs with the half-life of ^{60}Co or less, and some DSRSs with a half-life of less than 31 years, with respect to specified activity limit/source.

FAVL shallow disposal potential for acceptance of DSRSs is not yet established and will depend on the safety scenarios 500 years after the disposal facility has closed.

Geological disposal should be able to receive all other DSRSs, with the exclusion of tritium sources. DSRS waste packages will be oriented to HAVL or MAVL depending on the thermal output of the DSRS waste package. Tritium DSRSs will need a specific solution with long interim storage due to very low acceptance criteria at CSFMA for tritium waste.

5. CEA STRATEGY

For many years, the CEA has been the sole sealed sources producer in France. In 1984, high activity ^{60}Co and ^{137}Cs source production was transferred to CIS bio international. In 1999, low activity source production was transferred to AREVA-CERCA/LEA, and, eventually, the CEA stopped the production of alpha and neutron sources in 2008.

Furthermore, the CEA created in 2009, together with its former subsidiary, CIS bio international, a public interest group (GIP sources HA) mainly focused on the collection, recovery and disposal of ^{60}Co and ^{137}Cs high activity sources. The CEA has elaborated a strategy for the management of a very large variety of DSRSs, including those collected by GIP sources HA.

DSRS are collected from French users and from some French suppliers and stored at three facilities on the basis of radiological protection criteria:

— Highly irradiating beta–gamma sources, most of them ^{60}Co and ^{137}Cs, are collected by the CISBIO facility INB29, in Saclay;
— High level alpha or neutron sources, most of them ^{238}Pu, ^{241}Am and americium–beryllium collected by the CEA facility INB148, in Marcoule;
— Other sources (with low irradiation levels) are collected by the CEA facility CERISE located in INB47, in Saclay.

Pursuant to the PNGMDR, as revised in 2009, the CEA has started to implement elimination systems for all types of DSRS as follows:

— The recycling of batches of sources, in cooperation with the sources manufacturer (thus requiring their export most of the time);
— The return of some batches of sources to their initial producer or their country of origin (thus requiring their export);
— The destruction of some specific types of DSRS: tritium sources, gaseous sources, liquid sources, and incinerable plastic or resin sources. These sources are then managed in waste processes with no more sealed source specificity.

All other sources will be managed in four specific processes, derived from existing solutions that will be adapted to the specificity of the DSRS. Table 3 provides a global indication of the quantities involved.

— DSRS with a half-life of less than one year will be evacuated to CSTFA using 1 m^3 metallic baskets.
— DSRS with a half-life lower or equal to ^{60}Co, ^{152,154}Eu sources and ^{133}Ba sources will be managed using 5 m^3 cemented packages produced at the CSFMA Andra site. Source batches will be prepared in different types of primary containments providing adequate radiological protection.

- All other DSRSs will be accepted in 0.9 m^3 cemented packages produced and stored at CEA Cadarache, waiting for the availability of MAVL geological disposal. For smoke detector americium sources, two alternative solutions are under study: recycling and FAVL disposal.
- Nevertheless, some existing stockpiles of sources with high thermal output will be conditioned in 0.2 m^3 welded drums and stored at CEA Marcoule, waiting for the availability of HAVL geological disposal. This includes ^{90}Sr sources from radioisotope thermoelectric generators, high activity ^{137}Cs sources, and ^{238}Pu sources from pacemakers.

TABLE 3. DSRS WASTE PACKAGE PRODUCTION PLANNED BY THE CEA

Disposal		Sources to be managed		Waste package	Total volume (m^3)
		No.	Activity (TBq)		
CSTFA	Surface disposal	700	0	1 m^3 metallic basket	4
CSFMA	Surface disposal <120 watts/package	10 000	30 000	5 m^3 cement package	200
MAVL	Geological disposal <10 watts/package	400 000[a] + 6 000	1 000	0.9 m^3 cement package	160[b]
HAVL	Geological disposal <200 watts/package	6 000	12 000	0.2 m^3 metallic drum	1

[a] The large numbers are 241Am smoke detector sources.

[b] Including 120 m3 for historic cemented packages of 3ED3 each.

The CEA objective is to open the different routes for the management of DSRS as radioactive wastes within two years (three years maximum). This will require many specific authorizations.

6. THE PNGMDR WORKING GROUP

A specific working group has been created in the framework of the PNGMDR. This group includes representatives of all stakeholders: producers, suppliers, users, Andra, the Institute for Radiological Protection and Nuclear

Safety (Institut de radioprotection et de sûreté nucléaire) and French Nuclear Safety Authority (ASN, Autorité de sûreté nucléaire) observers. The group has already produced the first batch of recommendations for the improvement of the global management of DSRSs in France. A new report will be produced at the end of 2014.

The first priority is to complete, amend or confirm the Andra specifications for acceptance of DSRSs in the different existing or planned disposal sites.

In parallel, the CEA and Andra will review their planned waste systems for sources with the following objectives:

— The CEA and Andra solutions should cover all types of DSRSs.
— The solutions should be available and accessible to all authorized stakeholders (in most cases, the suppliers who collect DSRS from the users).

ASN will review the existing regulatory framework to take into account the new situation resulting from the creation of waste management solutions for DSRSs, and the feedback after ten years of practice of the 2002 revision of the Public Health Code, with respect to DSRS management.

7. CONCLUSIONS

My conclusion will propose some recommendations of general interest on the basis of French experience:

(a) Safe and secure interim storage is a necessary first step in any DSRS management strategy.
(b) Interim storage is not a long term solution. Each State should plan for effective elimination of DSRSs, using an optimized mix of the following solutions:
   (i) Return some DSRSs to the supplier or the country of origin;
   (ii) Recycle some DSRSs;
   (iii) Manage all other DSRSs as radioactive waste.
(c) Management of DSRSs as radioactive waste requires two conditions:
   (i) Elaborate the national strategy for the management of radioactive waste;
   (ii) Take due account of the specificities of DSRSs (attractiveness and concentration).
(d) Difficult transport issues have to be solved, due to the following:
   (i) The lifetime of sealed radioactive sources and devices is much longer than that of transport agreements;

(ii) International transport of very high activity DSRSs in Type B packages is very expensive and can easily become an administrative and logistics nightmare, with the consequence of large uncertainties on final cost.

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IMPLEMENTATION OF THE BOREHOLE DISPOSAL PROJECT FOR DISUSED SEALED RADIOACTIVE SOURCES IN THE PHILIPPINES

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Abstract

The Philippine Nuclear Research Institute currently manages radioactive waste generated from the various applications of radioactive materials in medicine, industry and research through its centralized treatment and storage facilities on site. Treated and conditioned wastes are temporarily stored in simple, roofed, above ground concrete bunkers. To date, a potential site for the co-location of near surface and the borehole disposal of disused sealed sources (BOSS) disposal facility has been identified for detailed investigation with the assistance of the IAEA. The preferred site is located in the northern part of the Philippines and has about 40 ha for potential development. A drilling programme that aimed to investigate further the geologic, hydrogeologic and hydrologic properties of the site has been carried out. Based on the current results of investigation, the design concept of the proposed BOSS facility as well as preliminary radionuclide transport calculations have been conducted. The paper presents the current status and initiatives that have been implemented for the borehole disposal concept of high activity sources in the Philippines. It focuses on the results of the drilling programme, the proposed design for consideration and the initial safety assessment of the site resulting from the disposal of major radionuclides from the waste inventory.

1. INTRODUCTION

Disused radioactive sources are generated throughout the Philippines from the peaceful applications of radioactive materials in medicine, industry, research and education. All licensed facilities are expected to manage the waste generated from their application in accordance with the radioactive waste provisions in practice specific code of Philippine Nuclear Research Institute (PNRI) Regulations. Three options are recommended for the management of disused sources. Either they are transferred to an authorized person, returned to supplier or manufacturer, or disposed of to an authorized person or facility.

The Philippines has only one facility for radioactive waste treatment, conditioning and storage (see Fig. 1). This facility is owned and operated by the PNRI and is located inside its compound in Quezon City. The facility has a total land area of about 4000 m^2 and a floor area of about 600 m^2. The facility includes the following:

— Wet laboratory for R&D activities;
— Shielded cell and decontamination room;
— Compressive strength testing area for concrete specimens;
— Decay storage room;
— Chemical precipitation area;
— Cementation area for conditioning process;
— Compaction area for compactible waste.

FIG. 1. PNRI interim storage facilities.

The storage room for decay has a volume of 100 m^3. The interim storage has an opening on one end with access from the radioactive waste management facility building. The facility has a truck entrance leading to the basement level of the building. This serves as the only entrance for large and heavy waste packages for management as well as the emergency exit for personnel in case of emergency. At present, two above ground, simple roofed concrete enclosures, with a maximum capacity of 315 m^3 and 220 m^3, respectively, serve as the interim storage for conditioned waste. After undergoing treatment and conditioning, waste is stored in these enclosures awaiting final disposal. An additional roofed bunker is underway to accommodate incoming waste, particularly those generated from the proposed decommissioning of the PNRI research reactor.

Recognizing that a national waste repository will provide a sustainable solution to the long term management of radioactive waste in the country, the Philippine Government, led by the PNRI, in collaboration with other government agencies committed to the development of a radioactive waste disposal facility. The site selection process resulted in the identification of a preferred site located in the northern part of the country. To take advantage of the benefits provided by shared infrastructures and R&D work, a study and evaluation of the co-location of a near surface repository and a deep borehole disposal facility for disused sealed sources is currently in progress. Initial evaluation of the current radioactive waste inventory showed that a number of disused radioactive sources are not acceptable in a near surface repository. The IAEA recommended that a deep borehole disposal (BOSS) facility would be the preferred option for these sources. The IAEA describes the borehole disposal concept as “the emplacement of solid or solidified radioactive waste in an engineered facility of relatively narrow diameter bored and operated directly from the surface” [1]. A range of design concepts have depths ranging from a few metres to hundred metres and a diameter from a few tens of centimetres to more than 1 m. On the other hand, a near surface repository involves emplacement of the waste on the surface or at a shallow depth up to a few tens of metres from the surface.

2. INVENTORY OF DISUSED RADIOACTIVE SOURCES

The following figures illustrate the variety of radioactive waste generated from industry (Fig. 2), research facilities (Fig. 3), medical applications (Fig. 4) and other applications (Fig. 5). All these radioactive waste are temporarily stored at the PNRI interim facility.

FIG. 2. Radioactive waste in industry: gauges, static eliminators, radiographic sources, smoke detectors and gas mantles (courtesy of RPS, NSTD and PNRI).

FIG. 3. Radioactive waste in research and educational institutions: std/check/reference sources, rugs, paper towels and vials (courtesy of RPS, NSTD and PNRI).

The inventory of spent sealed sources conditioned in 200 L drums and 1 m^3 containers represent a total volume of 25.4 m^3. This volume is composed of eighty-two 200 L drum and nine 1 m^3 steel containers. As indicated in Table 1, the total activity at the time of conditioning is 4.12×10^{14} Bq. The main contribution is due to ^{60}Co and ^{137}Cs, with all other radionuclides contributing less than 0.1% of this value. Note that only ^{137}Cs and ^{226}Ra have activities still considerably higher than 1 GBq after 300 years of decay. The preferred disposal option for both radionuclides would be borehole disposal.

FIG. 4. Radioactive waste from medical applications: teletherapy, brachytherapy, media culture and eye applicators (courtesy of RPS, NSTD and PNRI).

FIG. 5. Radioactive waste from abandoned scrap metal shipment (courtesy of RPS, NSTD and PNRI).

TABLE 1. INVENTORY OF CONDITIONED DISUSED SOURCES

Radionuclide	Half-life (years)	Activity (Bq)	Activity (Bq), 50 years after	Activity (Bq), 100 years after	Activity (Bq) 300 years after
Am-241	433	4.70E+10	4.34E+10	4.00E+10	2.91E+10
Ba-133	10.53	3.53E+03	1.31E+02	4.89E+00	0
Cd-109	1.27	9.91E+07	0	0	0
Co-57	0.74	1.66E−03	0	0	0
Co-60	5.3	3.03E+14	4.38E+11	6.33E+08	2.77E−03
Cs-137	30	1.09E+14	3.43E+13	1.08E+13	1.06E+11
Fe-55	2.7	4.56E+09	1.21E+04	0	0
H-3	12.3	1.15E+10	6.87E+08	4.10E+07	5.23E+02
Kr-85	10.8	2.23E+10	9.01E+08	3.64E+07	9.69E+01
Pm-147	2.62	3.25E+09	5.85E+03	0	0
Sr-90	29	2.80E+10	8.48E+09	2.57E+09	2.15E+07
Tl-204	3.78	9.29E+05	9.69E+01	0	0
Ra-226	1600	3.77E+10	3.69E+10	3.61E+10	3.31E+10
Total activity		4.12E+14	3.48E+13	1.09E+13	1.68E+11

Activities of unconditioned spent sealed sources and teletherapy sources are provided in Tables 2 and 3, respectively. The overall total activity is 5.88×10^{14} Bq. On the basis of the 1 GBq criterion, the majority of radionuclides shown in Table 2 would be provisional acceptable in a surface repository, with the exception of ^{241}Am, ^{238}Pu and ^{226}Ra. All other radionuclides have sufficiently smaller initial activities or their activities would sufficiently decay during the institutional control period.

TABLE 2. INVENTORY OF UNCONDITIONED SPENT SEALED SOURCES

Radionuclides	Half-life (years)	Volume (mm^3)	Activity (Bq)	Activity (Bq), 50 years after	Activity (Bq), 100 years after	Activity (Bq), 300 years after
Am-241	433	1.90E+05	4.05E+11	3.74E+11	3.45E+11	2.51E+11
Cd-109	1.27	n.a.[a]	2.05E+04	0	0	0
Cf-252	2.6	1.54E+03	8.07E+07	1.32E+02	2.14E−04	0
Co-57	0.74	1.43E+03	2.15E+06	0	0	0
Co-60	5.3	8.50E+08	2.94E+14	4.26E+11	6.16E+08	2.71E−03
Cs-137	30	8.74E+03	3.16E+11	9.96E+10	3.14E+10	3.09E+08
Fe-55	2.7	4.55E+04	8.15E+08	2.18E+03	0	0
H-3	12.3	5.89E+03	6.67E+10	3.99E+09	2.38E+08	3.04E+03
Ir-192	0.2	4.50E+02	7.54E+08	0	0	0
Kr-85	10.8	1.40E+04	3.18E+08	1.29E+07	5.20E+05	1.39E+00
Ni-63	100	1.05E+02	1.88E+09	1.33E+09	9.40E+08	2.35E+08
Pb-210	20.4	n.a.	2.07E+04	3.79E+03	6.93E+02	7.76E−01

TABLE 2. INVENTORY OF UNCONDITIONED SPENT SEALED SOURCES (cont.)

Radionuclides	Half-life (years)	Volume (mm^3)	Activity (Bq)	Activity (Bq), 50 years after	Activity (Bq), 100 years after	Activity (Bq), 300 years after
Pm-147	2.62	4.87E+03	9.19E+09	1.66E+04	0	0
Pu-238	87.7	n.a.	1.16E+10	7.81E+09	5.26E+09	1.08E+09
Ra-226	1600	1.79E+04	1.94E+09	1.90E+09	1.86E+09	1.70E+09
Sr-90	29	2.36E+03	6.28E+10	1.90E+10	5.76E+09	4.84E+07
Tl-204	0.01	1.58E+03	4.82E+05	0	0	0
U-238	4.46E+09	n.a.	7.00E+02	7.00E+02	7.00E+02	7.00E+02
Total activity			2.95E+14	9.34E+11	3.91E+11	2.54E+11

[a] n.a.: not applicable.

Note: Cobalt-60 and ^{137}Cs also need to be disposed of. Note again that this preliminary classification still requires confirmation by means of a detailed consequence analysis. Furthermore, since the sources are not yet conditioned in principle, all sources could be considered for borehole disposal based on the BOSS concept.

TABLE 3. INVENTORY OF UNCONDITIONED TELETHERAPY SOURCES

Radionuclide	Volume (mm^3)	Activity (Bq)	Activity (Bq), 50 years after	Activity (Bq), 100 years after	Activity (Bq), 300 years after
Co-60	6.54E+07	4.95E+13	7.17E+10	1.50E+05	0
Co-60	6.54E+07	5.40E+13	7.82E+10	1.64E+05	0
Co-60	6.54E+07	7.36E+13	1.07E+11	2.23E+05	0
Co-60	6.54E+07	2.67E+13	3.87E+10	8.10E+04	0
Co-60	6.54E+07	1.91E+13	2.77E+10	5.80E+04	0
Co-60	6.54E+07	1.91E+13	2.77E+10	5.80E+04	0
Co-60	6.54E+07	2.73E+13	3.95E+10	8.28E+04	0
Co-60	6.54E+07	7.70E+12	1.11E+10	2.34E+04	0
Co-60	6.54E+07	5.43E+11	7.86E+08	1.65E+03	0
Co-60	6.54E+07	4.62E+11	6.69E+08	1.40E+03	0

TABLE 3. INVENTORY OF UNCONDITIONED TELETHERAPY SOURCES (cont.)

Radionuclide	Volume (mm^3)	Activity (Bq)	Activity (Bq), 50 years after	Activity (Bq), 100 years after	Activity (Bq), 300 years after
Co-60	6.54E+07	1.47E+13	2.13E+10	4.46E+04	0
Co-60	6.54E+07	2.83E+11	4.10E+08	8.59E+02	0
Co-60	6.54E+07	7.69E+10	1.11E+08	2.33E+02	0
Total activity		2.93E+14	4.25E+11	8.89E+05	0

3. CONDITIONING OF SPENT HIGH ACTIVITY RADIOACTIVE SOURCES

The PNRI is one of the beneficiaries of the IAEA project to improve safety and security of disused sources in developing countries. The IAEA provides assistance by conducting an assessment of disused sealed sources inventory and performing long term conditioning. The PNRI has in its store 22 high active disused sources in various conditions from fresh, slightly deteriorated and oxidized state (see Figs 6 and 7).

Table 4 presents the inventory of unconditioned spent high activity radioactive sources planned for long term conditioning. The IAEA contracted the South African Nuclear Energy Corporation (Necsa) to perform the conditioning of these sources during the period of March to April 2013. Figure 8 shows the fully assembled mobile hot cell installed by Necsa at the PNRI site. Necsa furnished all the required resources such as qualified personnel, equipment, materials and facilities to safely remove the high gamma emitting sealed sources from their shields/assemblies or storage containers.

Only 16 out of 22 sources were successfully conditioned by Necsa. This includes 13 units of ^{60}Co teletherapy sources with total activity of 1.95×10^{14} Bq and 3 units of irradiator sources with total activity of 8.16×10^{12} Bq. These sources are now contained in long term storage shield. The other six sources were left unconditioned due to their physical condition. These include five teletherapy and one irradiator source, with a total activity of 7.2×10^{13} Bq and 1.14×10^{12} Bq, respectively.

FIG. 6. Teletherapy sources for conditioning.

FIG. 7. Irradiator sources for conditioning.

TABLE 4. SEALED SOURCES FOR CONDITIONING

Type	Source	No. of units
Teletherapy (various brands and make)	Co-60	18
Seed irradiator	Cs-137	1
Garden irradiator	Co-60	1
Irradiator from research reactor (in original transport container)	Co-60	1
Irradiator from research reactor (in fabricated stainless steel container)	Co-60	1

FIG. 8. Installed mobile hot cell at the PNRI conditioning area.

4. SITE INVESTIGATION FOR THE BOSS FACILITY

A preferred site located in the northern part of the Philippines has been identified for the co-location of near surface disposal vaults and the BOSS facility for disused sealed radioactive sources (see Fig. 9). The site is located on top of a hill and is characterized by intensely altered volcanic rocks which, although undated, are assigned an Oligo-Miocene age in the literature. These are overlain by a similarly undated but probably Pleistocene limestone, which occupies the low lying hills around its footprint. The footprint has an area of about 40 km^2 for potential development.

Given the technical requirements and depth of the BOSS facility, a deeper subsurface investigation of the site needs to be conducted. Concerns about the hydrogeologic and hydrogeochemical properties of the rocks that will impact the long term isolation of the waste will need to be addressed. In order to develop a site specific borehole concept, drilling of an investigation borehole to a depth of at least 100 m in a proper location will be necessary. To support the selection of the location of this investigation borehole, geophysical survey is required prior to drilling the borehole. Geophysical measurements provide insight into structural features that are keys to developing a comprehensive understanding of groundwater flow. It will also identify zones with low probability of faults being present and thus suitable for developing a BOSS facility.

FIG. 9. Preferred site for the co-location of the BOSS facility and near surface disposal vault.

It is the intent of the proponent that the investigation borehole, if found appropriate, could be developed into a borehole disposal facility in the later stage of the programme. The borehole should be developed within hydrogeological layers that have sufficiently low hydraulic conductivity and hydrogeochemical properties that are not aggressive to the disposal containers. The proposed location should be outside the estimated potential contamination window of the proposed near surface disposal vaults.

4.1. Application of the 2-D electrical resistivity survey

Geophysical exploration by electrical resistivity technique has been applied at the site to investigate and establish geological structures. This technique has been applied to active faults and fractured structures for several hundred metres deep and the resulting models were verified in detail by geological evidence from drilling or trenching to obtain more accurate resistivity profiles.

Figure 10 shows the layout of the two 1 km long resistivity lines along the undulating to plateau peak and side slope terrain at the site, while Fig. 11 displays the different equipment used during the survey. The two 1 km long resistivity lines are combinations of 20 individual electrical resistivity lines conducted at 205 m surface length to cover the displacement of data analysis at every edge of the profile. Results of the field survey were analysed using the 2-D Wenner Inversion technique. To determine the presence of faults/fractures from the

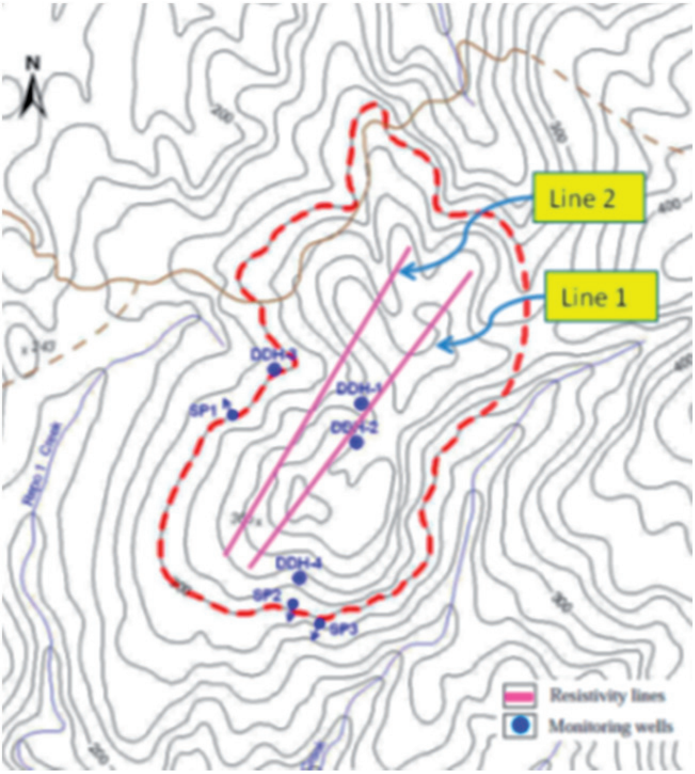

FIG. 10. Layout of the resistivity lines installed at the site.

FIG. 11. Sets of resistivity equipment used.

resulting profiles, the subsurface electrical profile was interpreted by the existing vertical layers imaging and possible layer displacement.

Electrical resistivity profiles of lines 1 and 2 illustrate varying signatures, such as wavy circular to vertical resistivity anomalies of relatively higher resistivity values. Overlain wavy circular higher resistivity is commonly an extent of exposed andesitic boulder outcropped on the surface particularly to the left section of the profile and side slope at right section while underlain higher resistivity layers are inferred impermeable solid or fractured andesite deposit. Low resistivity layer which is weathered andesite commonly detected at depression area. This is residual soil/andesite tuff deposit which has capacity to stored more volume of groundwater compared to higher resistivity layers.

Results of this preliminary investigation showed no evidence of fault or displacement detected along the two resistivity lines. The proposed location of the BOSS facility should be on higher resistivity layer where no suspected geological fractures.

4.2. Drilling campaign and preliminary results

Given the results of the electrical resistivity survey, a drilling campaign was initiated at the project site in 2012 (see Fig. 12). The primary purpose of the drilling campaign would be to drill up to a depth of approximately 100 m to obtain additional data on the deeper hydrogeological structures of the site.

FIG. 12. Drilling of a 100 m deep investigation borehole.

This will support the further refinement of the conceptual hydrogeological model as well as to evaluate the borehole disposal concept. Confirmation of the site's suitability in terms of the presence of a host formation characterized by a sufficiently low hydraulic conductivity and hydraulic gradient, absence of groundwater aggressive to the engineered barriers, and good sorption properties will be addressed. The drilling campaign made use of a Toho D2 K92 P2 multipurpose drilling machine. The machine is characterized by a twin cylinder, oil hydraulic feed system, spindle type drilling machine.

Results of drilling showed a 1.45 m thick soil mantle consisting of clay of varying plasticity. Standard penetration test N values are indicative of soft soil consistency within the upper layer (about 5.0 m thick) while the underlying layer is generally stiff to hard.

The underlying rock formation (from 14.5 m until the termination of the borehole) is characterized as andesitic pyroclastics — specifically, agglomerate, tuff and tuff breccias. The range of rock quality designation of extracted rock cores is wide, from 0–25% to as high as 96%. Intact cores were subjected to unconfined compression tests, yielding unconfined compressive strengths were in the range of 8.69–11.80 MPa (see Figs 13 and 14).

Hydraulic measurements using packer tests at 92 m showed hydraulic conductivity (k) values in the range of 0.13–0.58 m/d in highly fractured tuff breccias. The hydraulic conductivity of the underlying soils, weathered rock and fractured rock are 15 m/d for solid and highly weathered rock, 0.23 m/d for tuff breccias (type 2) and tuff, and 0.02 m/d for agglomerate and tuff breccias (type 1).

FIG. 13. Cores recovered with a grey and red tinge.

FIG. 14. Cores recovered with very course lapilli (probably pumice).

5. PRELIMINARY DESIGN AND SAFETY ASSESSMENT OF THE BOSS FACILITY

The site specific conceptual design of the proposed BOSS facility is based on the IAEA recommendation. Assuming that the sources will be placed in standard container have type 316L stainless steel cylinder of 114 mm outside diameter, 250 mm long and 6 mm thick, the proposed disposal unit can hold up to 57 cylinders given that the vertical spacing between two cylinders is at 1 m.

The borehole is 100 m deep, with its lower 70% designated for disposal and the remaining 30% for plugging (see Fig. 15). The distance of 30 m between the surface and the disposal zone is to avoid the possibility of human intrusion. These two sections and their corresponding purpose will have to be considered in the other facilities or civil works to be done within the project site.

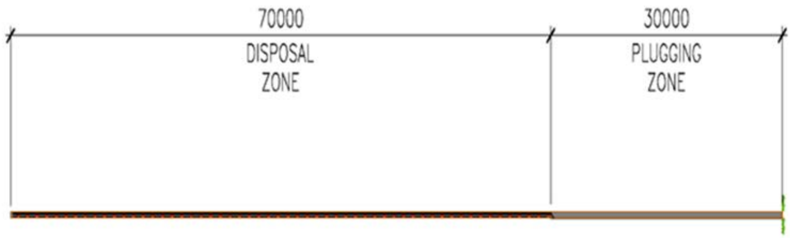

FIG. 15. Section of the proposed borehole disposal unit.

The diameter of the borehole disposal unit telescopes from 431.8 mm (17 in) at 30 m for the plugging zone to 381 mm (15 in) at 70 m for the disposal zone. These diameters are mainly limited by the available drilling equipment diameters in the country that can penetrate such depths. Conceptually, the borehole disposal unit is to have a depth of 100 m. Thus, the need is to only enlarge the current diameter. A borehole casing will be installed to provide support during operation by stabilizing the rock walls, avoid snagging of disposal packages and keeping the borehole dry. In the proposed borehole, type 316L or type 304 stainless steel will be used for casing. An anti-intrusion plate 385 mm long, 285 mm wide and 10 mm thick and made out of stainless steel angled 45° will be placed above the disposal zone to prevent subsequent drilling into the borehole.

Based on the results of investigation and the design concept, a preliminary radionuclide transport calculations has been performed. The 3-D simulation is presented in Fig. 16 from the shallowest, layer 2, to the deepest layer, layer 5. The direction of the plume spreads in an east to west direction from the borehole towards well 1 and well 2 from a high concentration to low concentrations. The wells 3, 4 and 5 are unaffected. At layer 2, the plume is relatively thin and of limited extent, which implies that the contaminant is being restricted by the rock. The deeper layers 3, 4 and 5 show a relative wider plume extent but still restricted in an east to west flow.

6. REMARKS

Further studies of the borehole disposal concept applicable to the preferred site will be continued. An analysis of the disposal canister in view of the projected disused radioactive sources inventory will also be evaluated. These studies will provide pertinent guidance and information on the performance of the source canister to ensure safe disposal or if the properties of the host/rock formation can provide additional containment.

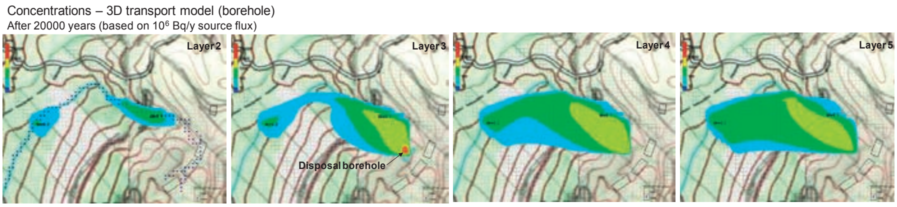

FIG. 16. Calculated radionuclide spread in groundwater for disposal borehole for a hypothetical continuous source of 1.0 × 10^6 Bq/a.

ACKNOWLEDGMENTS

The PNRI and the authors of this paper acknowledge with great appreciation the assistance provided by the IAEA particularly in the provision of technical experts, training of personnel and equipment in support of the Philippines' radioactive waste repository project.

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IAEA-CN-204/191

INTERNATIONAL INITIATIVES ADDRESSING THE SAFETY AND SECURITY OF DISUSED SEALED RADIOACTIVE SOURCES

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Abstract

International initiatives, aimed at improving the safety and security of disused sealed radioactive sources (DSRSs), that have been carried out during the last number of years are described in the paper. Issues to be addressed will include sustainability of current efforts, accidents and incidents, international standards and guidance, assistance provided to IAEA Member States, technologies developed for disused sealed source management and a description the development of the borehole disposal concept is given. New initiatives with regard to disposing of high activity DSRSs are elaborated.

1. BACKGROUND

Radioactive sources provide great benefit to humanity through their utilization in agriculture, industry, medicine, research and education, and the vast majority are used in well controlled facilities. Nonetheless, control has been lost over a small fraction of those sources resulting in accidents of which some had serious — even fatal — consequences. Indeed, accidents and incidents involving radioactive sources indicate that the existing regime for the control of sources still needs improvement [1]. Additionally, today's global security environment requires more determined efforts to properly control radioactive sources. Consequently, the current regimes need to be strengthened in order to ensure control over sources that are outside of regulatory control (orphan sources) [2], as well as for sources that are vulnerable to loss, misuse, theft or malicious use. Besides improving the existing situation, appropriate norms and standards at the national and international levels need to continue to be developed to ensure the long term sustainability of control over radioactive sources.

The IAEA has been involved in improving the cradle to grave control of sealed radioactive sources (SRSs) almost since its inception. As the production and use of sources has increased, so too has the amount of disused sources.

Initially, radium sources, which were found in many countries, were identified as being a safety risk, as they were no longer used. The IAEA started an initiative to bring these sources under better control in the early 1990s and this was followed by a paradigm shift after the events of the 11 September in the United States of America, when it was realized that much stronger efforts were needed to address the security concerns associated with radioactive sources. The IAEA rose to the challenge and launched projects in many countries to bring the higher activity sources under better control. The borehole disposal concept (BDC) and the mobile hot cell (MHC) were developed by the South African Nuclear Energy Corporation (Necsa) from 1995 to 2005, with the MHC having been successfully deployed and the BDC awaiting the first pilot operation.

2. ACCIDENTS AND INCIDENTS

Despite their predominantly small physical size, sources contain very high concentrations of radioactivity. Industrial and medical sources are typically in the GBq to PBq range. The radiation emitted from the sources is usually intense, requiring reliable encapsulation for operational use and heavily shielded containers for storage. Due to their small physical size, they are easily lost or misplaced if not properly managed. This is a particular problem when items of industrial or medical equipment containing sources become obsolete and are replaced, or simply scrapped, or when the sources weaken and need to be replaced. In all these circumstances, the sources are said to be ‘disused’. Poor management practices in many parts of the world have meant that disused sources have been found stored in exposed and unprotected locations and are consequently sometimes in poor condition, perhaps even leaking. There have been accidents and incidents recorded in the last 40 years involving fatalities as a result of sources being used in an inappropriate manner and being inadvertently mishandled by the public [1].

National regulations and international standards governing the manufacture and use of SRSs ensure that the source is safe when used as intended. In fact, prior to a major accident involving a sealed source in Goiânia, Brazil, in 1987 [3], it was widely believed that these regimes were effective in ensuring safety.

The Goiânia accident, caused by a ruptured ^{137}Cs source (50.9 TBq) from an abandoned and later dismantled teletherapy device, resulting in four fatal exposures, 28 cases of radiation burns, significant environmental contamination in the affected area, and large scale socioeconomic disruption, was the first of several accidents in the 1980s and 1990s that challenged the view that regulations and management systems of that time were effective to ensure safety. The IAEA has issued a series of reports on these accidents and lessons learned from them. The latest IAEA publication that summarizes many accidents involving sources was published in 2012 [1]. A serious accident occurred in May 2010 in New Delhi, India, where a self-shielded irradiator was sold to a junk dealer, who sold off some of the parts and dismantled others. Some of the source pencils were sawn open and the slugs of ^{60}Co were scattered around. One person died as a result of keeping one of the slugs in his wallet.

These accidents and incidents show that a small percentage of DSRSs are not properly controlled and international efforts should continue to bring vulnerable sources under control.

3. INTERNATIONAL STANDARDS AND GUIDANCE

One of the key elements in improving the control over DSRS and SRS in general is to improve the regulatory infrastructure in IAEA Member States. The IAEA has developed many documents that address this issue and is also tasked with producing and updating safety standards, technical documents and security related publications. These are usually produced in English and then translated into the various official languages of the IAEA. Member States who receive IAEA assistance are obliged to follow the requirements and guidance as set out in the Safety Series produced by the IAEA Department of Safety and Security.

The IAEA has a strong focus on assisting Member States to upgrade their regulatory infrastructure to meet the international requirements of the various conventions, safety standards and the Code of Conduct on the Safety and Security of Radioactive Sources [4]. This is done by sending “appraisal missions” to States and evaluating the regulatory infrastructure against the various benchmarks.

4. IAEA ASSISTANCE TO MEMBER STATES IN SOURCE RECOVERY

The IAEA provides assistance to Member States to build their own capacity to manage DSRSs by transferring technologies and know-how through staff training, expert advice and procurement of designs and equipment. In cases of urgency or a lack of adequate local infrastructure and human resources, the IAEA also provides direct assistance by sending qualified expert teams and mobile equipment to the country and solves the actual problems. To establish or upgrade

Member States' capacity to manage DSRSs, the IAEA provides generic designs for source conditioning/storage facilities. The designs can be modified to meet the specific needs of the Member State. The IAEA also offers staff training and technical procedures for handling, conditioning and storage of DSRSs.

The collection, conditioning and safe storage of disused radium sources was an early initiative of the Waste Technology Section (WTS) of the IAEA that is still going on today. The Spent Radium Sources Programme was started in 1991 [5]. Radium sources were used in medicine up to the late 1960s, when they were replaced by other radioactive sources such as ^{192}Ir in brachytherapy applications. Over 50 conditioning operations dealing mainly with radium sources have been concluded in many developing countries. The methodology employed by the WTS is described in Ref. [5]. Working procedures were developed and are still being updated as more experience is gained. The 'radium' experience has been used and extended in conditioning other disused sources and also in the conditioning of high activity sources. The essential elements of the methodology involve collection of the disused sources, removal from the devices if necessary, conditioning and storage in safe and secure conditions. Figures 1 and 2 show some elements of a conditioning operation for radium and americium sources conducted in an Asian country.

The conditioning involves placing the sources within a stainless steel capsule (see Figs 1 and 2), welding the lid on the capsule (see Fig. 3), leak testing the capsule and then placing the sealed capsule in a lead shield (see Fig. 4), which is then placed in a concrete lined drum (see Fig. 5).

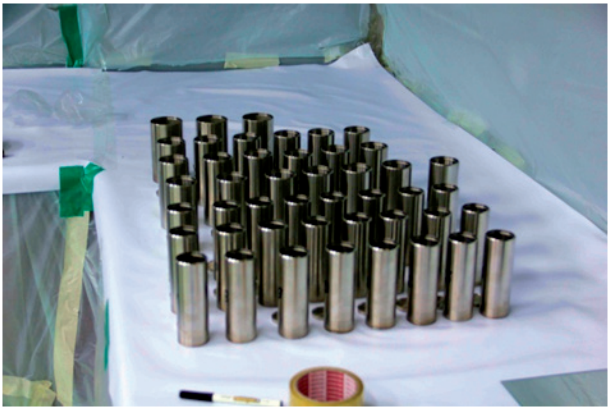

FIG. 1. Capsules lined up before sources inserted.

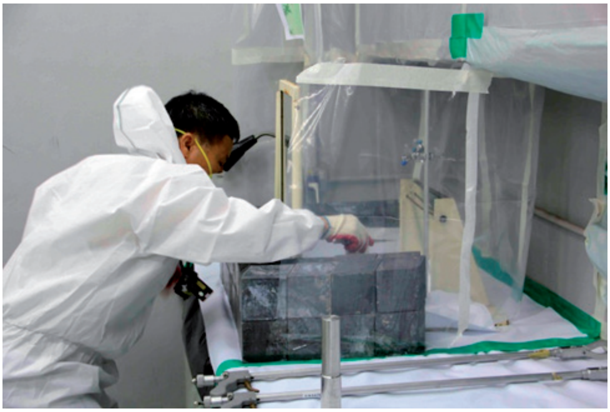

FIG. 2. Sources being dropped into a capsule.

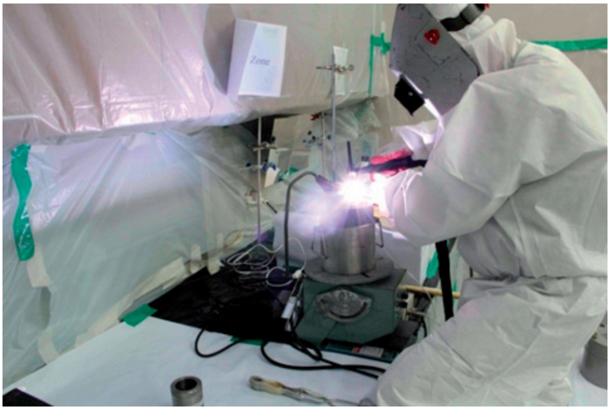

FIG. 3. Welding the capsule.

Expert teams from Member States are contracted by the IAEA (WTS) to carry out these operations and the expert teams currently being used come from Brazil, Hungary, the Republic of Korea and South Africa. Staff members of the IAEA in conjunction with international experts also train national teams to carry out this work if the number of sources in a country justify having a national team. In most other cases the expert teams are used for conditioning operations. The IAEA does not as a general rule recommend the removal of sources from gauges in developing Member States unless many months of training have been given to the staff that will carry out this work. This is also done by expert teams often in conjunction with a MHC operation.

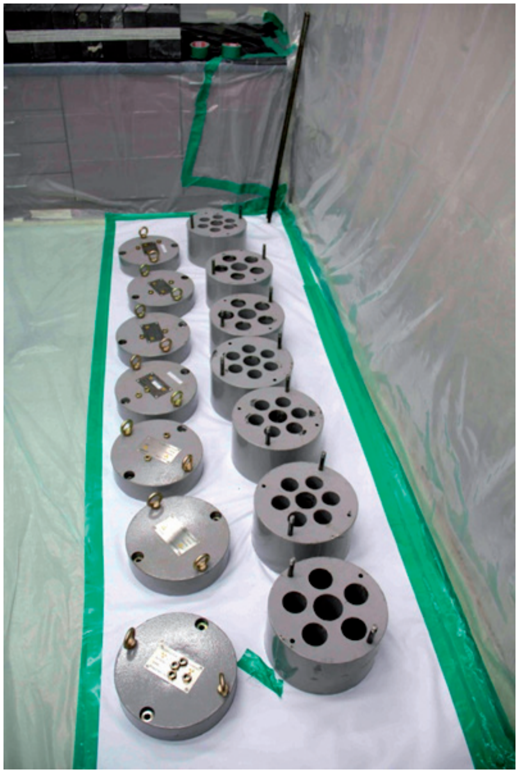

FIG. 4. Lead shields lined up waiting to receive capsules.

FIG. 5. Lead shield containing capsules placed in concrete lined drum.

The IAEA approach to providing assistance to Member States is outlined in a paper[1] at this conference and will not be elaborated here. Conditioning of high activity sources has now become routine and the IAEA has successfully conducted four operations in the Philippines, Sudan, the United Republic of Tanzania and Uruguay. In the case of Uruguay, sources from three different States (Canada, India and United States of America) were conditioned and then placed in transport containers for transport to their countries of origin. Figure 6 shows the MHC deployed in the United Republic of Tanzania. In the other countries, the sources were safely and securely stored in long term storage shields.

Other types of practical assistance provided include the deployment of experts to characterize and package DSRSs stored either at user premises or at a centralized store. Often, DSRSs are stored in a haphazard fashion, often without any record keeping. These missions individually characterize each source by removing the device from the store to a low background area and then measuring the dose and estimating the activity. If records exist, they are compared with the

FIG. 6. Mobile hot cell deployed in the United Republic of Tanzania.

[1] See IAEA-CN-204/227, in Session 6, pp. 477–488.

measurements and the result of the work is a verified inventory for the storage facility. No further activities such as removal from the country or disposal can be conducted without a verified inventory. This characterization step is vital for future planning of the disposition of the DSRS.

The security initiatives for securing high activity sources have resulted in a significant number of radioactive waste management storage facilities being built in a number of countries. These facilities are being funded by donors who have a 'security' focus and often the new store is very secure but not yet licensed for use. Significant delays are experienced in licensing as the security support more often than not does not include this step. The IAEA provides support in developing licensing documentation that the operator can submit to their regulator for approval to obtain authorization for the operation of the facility. The sustainability of the security and safety systems depends on developing a management system that is implemented according to best international practice. More often than not, the security systems installed in radioactive waste management facilities in developing countries that the author has visited are degraded with various elements not working. A continual problem experienced by these facilities is power failures. The large stand-alone generators installed by the donors are sometimes not used, as they are too expensive to run and maintain. Sustainability of the security system over the long term is therefore doubtful and the same concern can be expressed with regard to the management system for safety. There should of course be one management system for all elements of a radioactive waste management storage facility including both safety and security.

5. BOREHOLE DISPOSAL OF DSRSs

Disposal in boreholes is intended to be simple and effective, meeting the same high standards of long term radiological safety as any other type of radioactive waste disposal [6]. Intuitively, borehole disposal gives enhanced security over the long term storage of DSRSs and would be a more sustainable solution to the problem posed by DSRSs.

The BDC saw its birth in 1995 during an IAEA and African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology regional training course hosted by Necsa in Pretoria, South Africa. The African delegates reviewed their national radioactive waste management programs and among the issues raised were the lack of adequate storage facilities, the lack of disposal solutions and the lack of equipment to implement widely used disposal concepts for the long term management of their DSRSs. This led to a Necsa proposal to use a borehole type disposal concept as a potential robust but safe and secure long term solution for the management of DSRSs on the African continent. The BDC, as it is known today, developed out of those initial considerations [6].

Conceptually, the disposal concept comprises a borehole (150–260 mm in diameter) drilled down to a depth in the range of 30–100 m (see Fig. 7). The depth will be dependent on the site specific safety assessment. The borehole will have a casing with a plug at the bottom. Grouting will then be applied to seal the annulus and all fractures and crevices outside of the casing. The spacing of waste packages is approximately 1 m. The space between packages is backfilled with a suitable material such as cement or concrete grout. In the generic design of the BDC, a 100 m deep borehole is to be filled with 50 packages up to the depth of 50 m. The rest will be backfilled with concrete to act as a borehole plug [6].

The international peer review in 2005 of the BDC successfully concluded the development phase of the project which was initiated in 1996 [8]. The members of the peer review team gave a positive assessment of the technical feasibility, economic viability and overall safety of the BDC. Since 2005, two publications specifically dealing with disposal in a borehole have been developed by the IAEA [9, 10]. The technical manual can be used to guide implementers of borehole disposal in the steps to take when managing a borehole disposal project [9]. Figure 8 illustrates where disposal in a borehole fits in with the life cycle of SRSs.

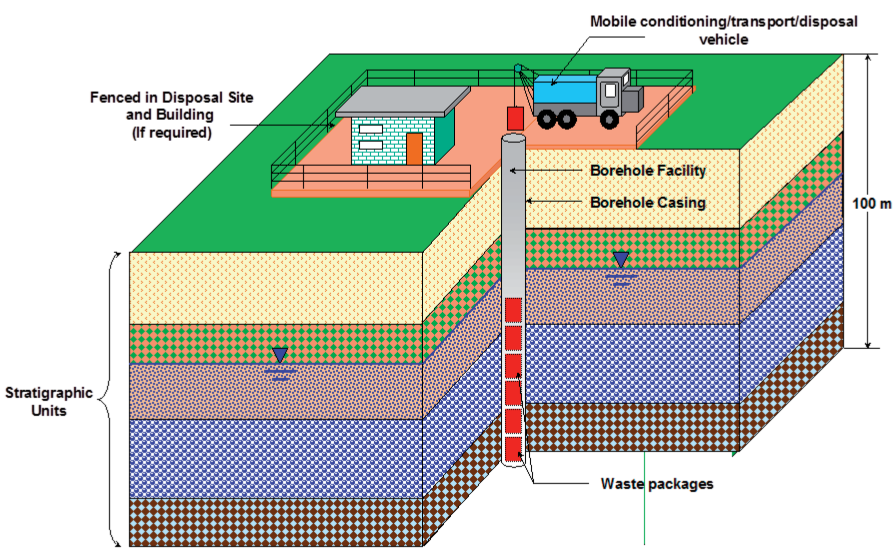

FIG. 7. Schematic representation of the borehole disposal concept (reproduced from Ref. [7]).

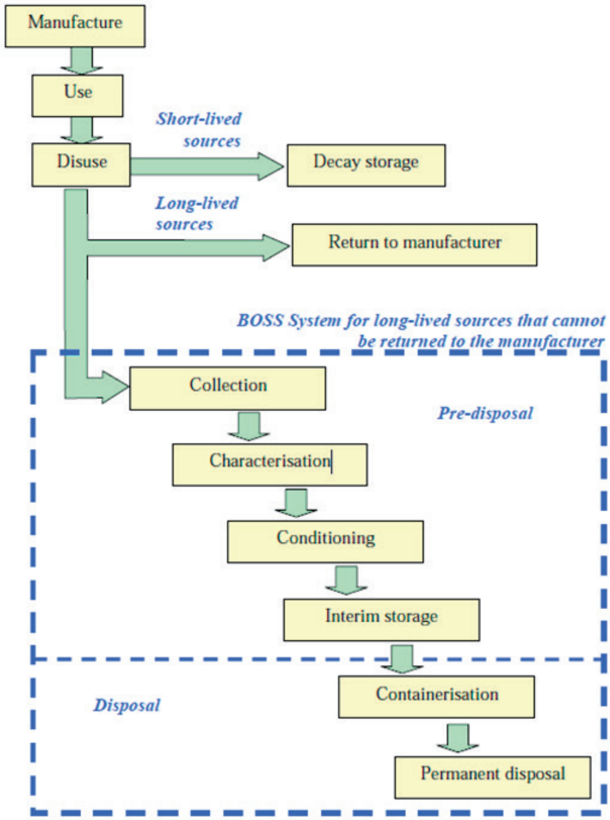

FIG. 8. Illustration of where disposal fits into the life cycle (reproduced from Ref. [9]).

It should be noted that not all the equipment to enable disposal of all types DSRS has as yet been developed. The transfer cask for the disposal of the lower activity sources has not been manufactured, although the design is complete (see Fig. 9) [11]. The operational facilities for the disposal of the higher activity Category 1 and 2 sources have neither been designed nor manufactured [12]. Conceptually, the MHC could be used in conjunction with the borehole disposal facility to dispose of these higher activity sources. The IAEA has budgeted to complete the operational equipment under a technical cooperation project (INT9176) which has received funding from the European Commission. The IAEA Technical Cooperation Fund will also contribute to this effort. The complete system for disposal of all categories of sources should be complete by the end of 2015.

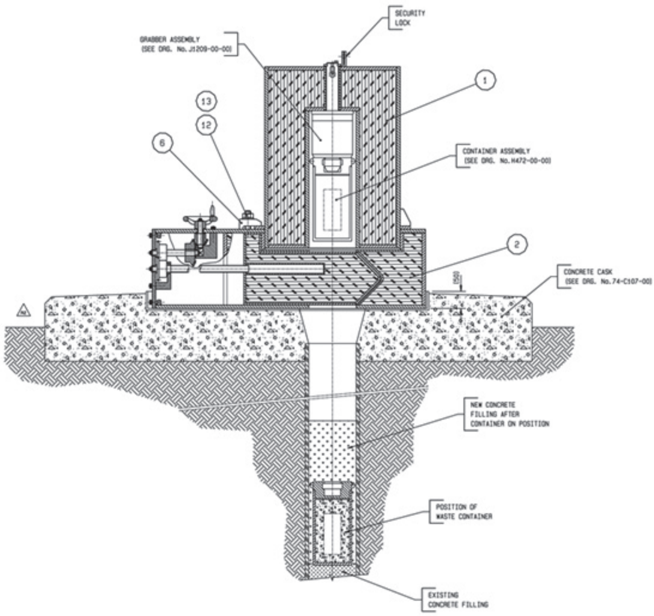

FIG. 9. Drawing of the transfer cask positioned over a borehole (reproduced from Ref. [11]).

A number of States are actively pursuing projects to implement borehole disposal, and three have already chosen sites and are carrying out characterization of those selected sites. During the next budget cycle (2014–2015) of the IAEA Department of Technical Cooperation, three national technical cooperation projects have received funding to pursue the implementation of borehole disposal in Brazil, the Philippines and Malaysia. There seems to be an upsurge of interest in this concept and it is hoped that a borehole will soon be used for the disposal of DSRSs.

6. CONCLUSION

The IAEA will continue supporting its Member States in a variety of areas to improve the control of SRSs throughout their life cycle. In particular, the following needs to be executed in order to complete the borehole disposal system [13].

The inclusion of high activity DSRSs into inventories to be disposed of using the BDC requires the integration of the concept with some alternative pre-disposal activities in order to allow for the safe handling of these sources.

In this regard, the Necsa MHC facility could be utilized successfully to condition and prepare the high activity DSRS waste packages for disposal and may even be utilized as shielding around the repository borehole. The MHC facility has been demonstrated and used successfully for the conditioning of DSRS for storage. Integration of the two concepts will, however, require some further development work in order to refine the waste packages preparation activities for disposal.

It is not until the specific characteristics of the inventory and site are known and have been incorporated into the long term safety assessment that the design of the borehole facility can be optimized [13]. For States with borehole projects already underway, the IAEA could focus its assistance on developing verified inventories and helping with site characterization. Once this is done the generic long term safety assessments can be used as a guide to conduct the site specific long term safety assessment that is a key component of the safety case that needs to be submitted to the regulator.

Once the pre-disposal equipment for high activity sources is designed and manufactured, the borehole disposal system will be ready for the disposal of all categories of DSRS (Categories 1–5) [12].

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IAEA-CN-204/116

LONG TERM SAFE AND SECURE MANAGEMENT OF DISUSED SOURCES IN TURKEY

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Abstract

Disused radioactive sources are generated from research and nuclear applications mainly in medicine, biology, agriculture, quality control in metal processing and construction industries. In the paper, implementation of technical steps for long term safe and secure management of disused sources in Turkey are presented. After classification and pretreatment of spent sealed sources, characterization of the each disused radioactive source was done by using appropriate analysis methods. Later on, the sources were dismantled from its original shield in hot cell and immobilized in a concrete/lead shield for long term storage.

1. INTRODUCTION

Radioactive sealed sources in Turkey are used in various applications in research, medicine, agriculture and industry. Radioactive sources that are no longer in use are called a disused source. Disused sources are defined as sources that are no longer used and there is no intention of using them again in the practices they were authorized for. Currently, the number of disused radioactive sources is increasing every day. For this reason, they should be taken into safe and secure management system. The safe management of disused sources in Turkey includes these steps: classification, pretreatment, conditioning and interim storage.

2. CLASSIFICATION AND PRETREATMENT OF DISUSED SOURCES

2.1. Classification

The disused source is received in a capsule. In this case, the hazard from external radiation has to be considered. In any case, possibility of contamination due to fracture of the capsule should be taken into account. The first classification of disused sources is based on the type of radiation: gamma, beta, alpha or neutron sources. In addition, the size of the disused sources is extremely variable. They are produced in many different designs according to their activities. Several examples of disused sources in Turkey are shown in Fig. 1. The volume of a high activity shielded disused source is generally large because of the shielding material.

Exemption criteria cover evaluation of risks and depend on source specifications. Basically, the half-life of the source should be shorter than 100 days in order to designate as exempt waste in Turkey. The next step is exposure risk, which should be evaluated. If it is lower than 0.01 mSv in a year, the second parameter is satisfied. And the last step is evaluation of annual limit on intake levels. According to this evaluation, these spent sources are separated from the others for decay storage.

FIG. 1. Disused sources.

Basically, classification step covers classification and identification. If the half-life of source is lower than 30 years, it is called a short lived radioactive waste. In addition, other criteria is available as a waste (such as <4000 Bq/m^3 for alpha emitters). Mainly sources are segregated into two groups:

— Short lived: transferred to interim storage for decay until exempted levels for disposal are reached.
— Long lived: conditioned in such a way that the source is made safe and then transferred to a proper interim store while awaiting eventual disposal.

2.2. Pretreatment

There are several pretreatment methods depend on the selected conditioning method. First and basic step of waste management is pretreatment. Pretreatment covers segregation and classification stages. Principally, pretreatment is an initial step to handle radioactive waste for being easy for conditioning and packaging. Segregation of radioactive waste into exempt and low level waste (LLW) streams. Separation of LLW streams into long lived and short lived waste streams is a further process:

— Retrieving the source from its original shield in the hot cell;
— Packaging of spent sources according to the transport and next steps;
— Recovering non-active materials for recycling.

The following requirements and other factors should be taken into account when planning a conditioning operation: such as smear tests on the source shield should be carried out to check for any leakage. Safety and radiation protection measures are taken according to radiation type by using appropriate measurement devices.

3. CONDITIONING OF DISUSED SOURCES

The difficulty of developing disposal alternatives for disused sources has offset many of the benefits of their use. Sources are used in numerous industrial, research and medical applications and are currently used in nearly every country in the world. The wide availability of sources, including several with relatively long lived isotopes, makes their collection and disposal very challenging. End-of-life disposition pathways for sources are few and vary widely from State to State. Therefore, long term surface or near surface storage remain the most commonly applied options [1]. Radioactive sources according to their half-lives are required long term interim storage to avoid the release of radioactive material and to limit radiation exposure. In this study, containment of the disused sources was achieved by high integrity encapsulation system. Special lead shielding devices were designed to limit radiation exposure. A 200 L drum was used as a conditioned waste package for the disused sources and represents a Type A package under the IAEA transport regulations [2].

The objective of management of disused radioactive sources is to produce a waste package acceptable for handling, transportation and interim storage. The waste package produced in a conditioning process needs to comply with the transport regulations and requirements for long term storage. Where long term disposal facilities do not exist, possible future retrieval of the conditioned sources has to be taken in consideration.

Decay chain should be taken into account: a radium source always contains ^{226}Ra and its daughter products. Radium-226 decays by alpha emission to ^{222}Rn, a noble gas with a half-life of 3.6 days. In the decay chain ending with the stable isotope ^{206}Pb, there are further eight radionuclides of which four are alpha emitters. Thus, each decaying ^{226}Ra atom gives rise to five alpha particles. In the decay, many low energy gamma photons and beta particles are also emitted has a rather high dose factor. Conditioning of ^{226}Ra also provides greater confinement of leaking spent ^{226}Ra sources and reduces exposure potential. It is required before long term interim storage to avoid the release of radioactive material and to limit radiation exposure. For this purpose, several techniques (active carbon box and capsules, among others) have been used in previous applications. In this study, high integrity encapsulation was achieved by special designed capsules. A shielding container was designed to maximize the physical security of disused sources (see Fig. 2) [3].

Conditioning is implemented on disused sources to produce an acceptable waste package for handling and storage in safe manner. For these reasons, the waste package produced in a conditioning process should comply with the transport regulations, requirements for long term storage and/or waste acceptance criteria for disposal, as applicable [4]. If waste acceptance criteria for disposal do not exist at the time of the conditioning, the waste package produced is to be fully characterized and the conditioning procedure has to take in consideration retrieving of the sources.

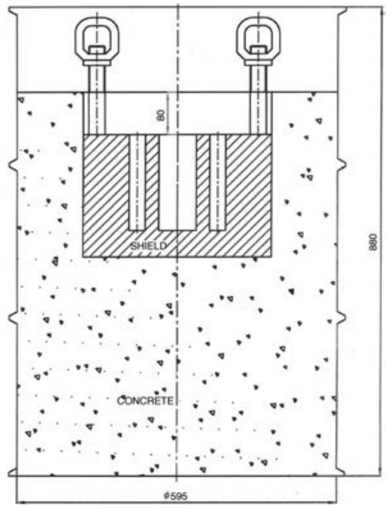

FIG. 2. Retrievable conditioned waste package.

4. INTERIM STORAGE OF DISUSED SOURCES

Several developed countries are researching deep geologic repositories and other permanent disposal options, but only a few have implemented these plans with operational sites, even fewer which dispose of sources, and none of which cover every category of source [5]. Disused radioactive sources generated from industrial, medical, and research centres. Most of the developing countries often do not have the national physical, regulatory and security infrastructures necessary to manage these materials at the end of their useful lives. Returning of disused sources to the supplier is still convenient method. Recycling and repatriation of sources should be considered in universally. Otherwise, an ultimate disposition pathway should be identified. In this manner, harmonization is required for source disposition for all source owners. In Turkey, disused sources are immobilized in capsules and cement matrices, which are then planned to store in near surface interim storage facility in future (see Fig. 3).

FIG. 3. Interim storage.

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IAEA-CN-204/129

EXPERIENCE IN THE MANAGEMENT OF DISUSED RADIOACTIVE SOURCES IN CUBA

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Abstract

Disused radioactive sources in Cuba, when they cannot be returned to the provider, are managed as radioactive waste by the Centre for Radiation Protection and Hygiene. They are collected and transported to waste management facilities, where they are characterized, conditioned and stored. The paper describes the different approached followed for conditioning the different types of disused radioactive sources and devices containing radioactive sources, such as lightning rods, smoke detectors and different kind of nuclear gauges.

1. INTRODUCTION

Sealed radioactive sources (SRSs) are widely used in Cuba in industry, medicine and research. According to national regulations, once SRSs are declared disused, they have to be returned to the provider [1]. When this option is not available, disused sealed radioactive sources (DSRSs) have to be managed as radioactive waste.

In order to reduce the risk associated with disused radioactive sources, the first priority would be to bring them under appropriate controls. It is important to have a proper infrastructure in the country for their safe and secure management. The Centre for Radiation Protection and Hygiene (CPHR, Centro de Protección e Higiene de las Radiaciones) is responsible for centralized management of DSRSs in Cuba. The National Nuclear Safety Centre (Centro Nacional de Seguridad Nuclear) is the regulatory authority for nuclear affairs. From 1990, a centralized storage facility for radioactive waste has been in operation in the country. DSRSs generated in different medical, industrial and research

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institutions are collected and transported by the CPHR and stored in this facility. Disused radioactive sources are conditioned to guaranty the safety during long term storage.

2. CHARACTERIZATION OF DISUSED SEALED RADIOACTIVE SOURCES

Several sources were received in the facility without the required information about the radionuclide contained and activity. It was extremely necessary to establish adequate control over disused radioactive sources at the centralized storage facility. The creation of proper inventory of DSRSs became a high priority. The first tasks were to characterize all the 'unknown sources' and implement an appropriate system for record keeping. Portable spectrometers were used for identification of the radionuclides (for gamma emitters). The activity was estimated from dose rates measured at a certain distance from the source [2]. An updated inventory of all stored wastes and DSRSs is kept at the CPHR.

3. CONDITIONING OF DISUSED SEALED RADIOACTIVE SOURCES

It is recognized that the conditioning of radioactive waste, including DSRSs, contributes to increasing their safety and security. The waste package produced is more appropriate for handling, transport, storage and/or disposal. As final disposal of radioactive waste has not been defined yet in Cuba, the DSRS has been conditioned to allow retrieval.

Disused radioactive sources have been conditioned for long term storage and according to their characteristics. The different approaches followed for conditioning the different kind of sources are described below.

3.1. Disused radioactive sources of Categories 3–5 containing radionuclides with a half-life less than 30 years

Disused radioactive sources containing radionuclides with a half-life less than 30 years are conditioned in pre-cemented 200 L drums (with a cavity in the centre). DSRSs, within their radiation shielding, are successively placed in the cavity until either the cavity is filled or until a limit of activity had been reached. The lid of the drum is placed on and locked (see Fig. 1). The void space between the devices is not grouted with cement, the devices and sources remain retrievable for further processing to meet future waste acceptance criteria for any type of disposal if necessary. Once a waste package is produced a formulary is filled

FIG. 1. Conditioning of disused radioactive sources with a half-life less than 30 years.

with all the information regarding its content. More than 600 DSRSs (i.e. nuclear gauges and industrial radiography sources, among others) have been conditioned following this procedure.

Some radioactive sources were contained in devices that were dismantled, and the sources recovered and placed in small containers in order to reduce the volume for conditioning, for example, the ice detectors used in aircraft (see Fig. 2). This device contains a ^{90}Sr radioactive source, located in the low part of the metallic cylinder, which is cover with a red metallic cap.

3.2. Disused radioactive sources of Categories 3–5 containing long lived radioactive material

A considerable number of disused radioactive sources containing radionuclides with a half-life more than 30 years (mainly ^{226}Ra and ^{241}Am) are stored in the facility. These DSRS have been conditioned following IAEA recommendations [3, 4]. The method involves the removal of the radioactive sources from their devices, over-encapsulating them and emplacing the capsules in a package providing both shielding and physical protection.

Most ^{226}Ra sources came from medical applications (brachytherapy sources). A large number of ^{241}Am radioactive sources were recovered from lightning conductors and smoke detectors. The procedure followed for recovering and conditioning these long lived sources is briefly described below.

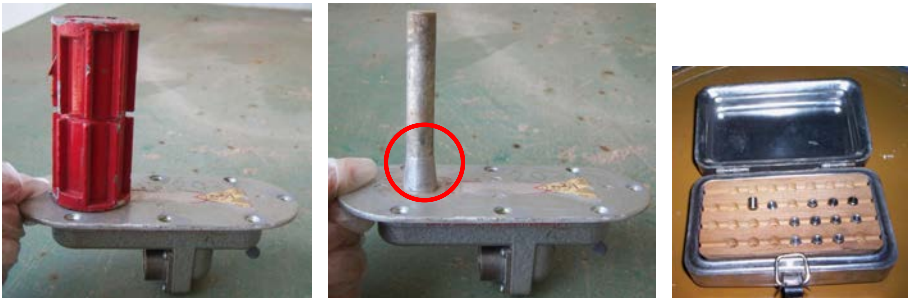

FIG. 2. Ice detectors used in aircraft and the contained ^{90}Sr radioactive sources.

3.2.1. Conditioning of ^{226}Ra sources

Radium-226 SRSs have been used in Cuba since the 1940s for brachytherapy services in several hospitals around the country. Following the international recommendations, the use of ^{226}Ra sources was discontinued and replaced by other radionuclides, such as ^{137}Cs, ^{60}Co and ^{192}Ir. Consequently, all ^{226}Ra sources (more than 1000) were collected from hospitals and transported to the centralized storage facility at the CPHR [5]. Disused ^{226}Ra sources were also collected from industries (well logging) as well as from research and educational institutions.

3.2.1.1. Inventory and segregation of ^{226}Ra sources

No information on the collected sources was available at the user's premises. The total quantity of radium stored at the centralized waste management facility was also unknown. This information was essential for planning the conditioning operations, therefore a thorough characterization of each source was needed to identify the radionuclide and to estimate the activities. Several radium tubes were stuck in different types of medical applicators, which were disassembled and the sources recovered (see Fig. 3).

A portable gamma spectrometer (model Exploranium) was used for radionuclide identification (to corroborate that it was ^{226}Ra). Source activity was estimated from the dose rate measured at a distance of 1 m from the source (considered the geometry for a point source) [2]. The results of characterization were adequately registered.

Once characterized, the brachytherapy sources were segregated in groups and placed in individual lead containers, so that the total activity per group did not exceed 1.85 GBq. This is the maximum activity of ^{226}Ra to be conditioned per capsule. In this way, 81 containers with 1009 brachytherapy radium needles and tubes were prepared. Another 62 sources were also characterized and registered.

FIG. 3. Recovering sources from applicators: characterizing ^{226}Ra sources.

They were sources used for well logging, teaching and control sources, among other things. At the end, a detailed and updated inventory of disused radium sources was prepared. Table 1 shows the summary of this inventory. Radiation and contamination levels at the surface of the containers with radium sources were also measured and recorded. These characterization/segregation operations were carried out under safe environment, with adequate ventilation and radiation protection measures.

TABLE 1. SUMMARY OF THE INVENTORY OF DISUSED ^{226}Ra SOURCES AT THE WASTE STORAGE FACILITY

Source type	Total amount	Activity (GBq)
Brachytherapy needles and tubes	1009	168.7
Other sources (e.g. well logging, control sources)	62	19.8
Total	1071	188.5

3.2.1.2. Authorization of radium conditioning operations

Radium conditioning was not included among the practices authorized under the Institutional License for the Operation of Waste Management Facilities. Therefore, it was necessary to request an additional authorization for these operations. The documentation supporting this request included the corresponding safety report, the procedures for all the operations and the emergency plan.

The safety report contained the safety instructions specifically related with the handling of disused ^{226}Ra sources. The preparation of suitable and adequate workplaces to handle the radiation sources was a basic principle observed in order to avoid unnecessary occupational exposure and spread of contamination.

The operational area for radium conditioning was set up at the waste processing facility. The operational areas were covered with plastic sheeting. The transfer area was erected with lead bricks and lead glass for shielding. A ventilation system — a high efficiency particulate air (HEPA) filter system — was installed above this workplace. Appropriate shielding was also used in the welding area and leak testing area.

According to the national regulation [6] and IAEA Safety Standards Series No. GSR Part 5, Predisposal Management of Radioactive Waste, General Safety Requirements [7], a safety assessment of all the operations involving the handling of radiation sources was performed in order to demonstrate that the facility and operations were adequately safe. The expected doses to be received by each operator were estimated taking into account the activities of ^{226}Ra sources to be handled, the designed shielding configuration at each workplace, the distance from the sources as well as the time required for each operation. The total effective doses for all the operators were well below the dose constrains established for the radioactive waste management practices, which is 10 mSv per year.

3.2.1.3. Conditioning of ^{226}Ra sources

Relevant equipment for radium conditioning in Cuba was provided by the IAEA. This included:

— Stainless steel capsules;
— Welding equipment;
— Rotating table for welding;
— Shielding containers;
— Mobile filtration system;
— Lead glass window.

Other important equipment and consumables were locally procured or prepared by the CPHR.

Radium sources in Cuba were conditioned following the methodology recommended by the IAEA [3]. The storage shields with sources were transferred one at a time to the capsule loading area, where the sources were transferred to the stainless steel capsules (see Fig. 4). The total activity in the capsule was verified by measuring the dose rate at a certain distance from it. When the capsule is completed the lid was placed into position. The dose rates and total activities in the capsules were recorded.

Once the capsule was loaded, it was transferred to the welding area, where the lid was welded and cooled. Welded capsules were submitted to leakage test, performed according to the ISO 9978 [8]. All the sources were sealed

FIG. 4. Conditioning of ^{226}Ra radioactive sources.

in 84 stainless steel capsules, 77 standard and 7 big capsules. Five standard capsules failed the leakage test, they were rewelded. After the test, the sealed capsules were transferred to the appropriate cavity of the final shielding device (see Fig. 4).

Once the shielding container was completed with the sealed capsules, the lid was placed and secure with the screws. Additionally, the lead shielding device and its lid were welded together to protect the sources against unintentional or unauthorized opening. The shielding containers were identified with a code. The dose rates and surface contamination were measured and registered.

Shielding devices with the capsules were placed in concrete lined drums. Five waste packages were produced with conditioned radium sources. The compliance with the waste acceptance criteria for the storage facility were controlled and recorded: identification of the waste package, radiation levels at the surface and at 1 m, radioactive content (radionuclides and activities) and the surface contamination. The formulary for the waste package contains a detailed description of the package, the shielding devices and the capsules with radium sources.

3.2.2. Management of radioactive lightning rods

Radioactive lightning rods (RLRs) contain radioactive sources (e.g. ^{241}Am, ^{14}C and ^{226}Ra, among others) attached to the end of the metal conductor. There is no convincing scientific evidence to support that lightning rods containing radioactive sources are more effective than standard non-radioactive alternatives. So from the radiation protection point of view, the use of these devices is not justified. Moreover, with time, it was determined that most of these devices presented radiation protection problems — in particular, leakage of loose contamination in the case of the ^{241}Am and ^{226}Ra sources.

Following the international recommendations, Regulation 58/2003 [9] came into force in Cuba in 2003, prohibiting the import and installation of new devices and requiring the users to dismantle the installed devices and manage them as radioactive waste in a period of ten years (by 2013). More than 150 RLRs have been collected by the CPHR in the past ten years and stored at the centralized waste management facility.

In order to improve the safety and security of the long lived sources (mainly ^{241}Am) and minimize the volume of waste in the storage facility, it is recommended to dismantle those devices, remove and consolidate the sources and condition for long term storage. Other components of the device, not containing the radioactive sources, are monitored for contamination and managed accordingly.

3.2.2.1. Inventory of radioactive lightning rods in the storage facility

Different models of radioactive lightning rods have been collected from several industries around the country. Most of them are Helita, Ionocaptor and Indelec, containing ^{241}Am or ^{226}Ra sources. Relevant information about the devices and the radioactive sources were available at the users, as they were controlled by the regulatory body. According to national regulation [6], authorization was required for the use of radioactive lightning conductors. Nevertheless, some devices were collected before this regulation came into force, and for some of them no information was available. These devices were characterized, the radionuclide was identified using a portable spectrometer and the activity estimated (for gamma emitting radionuclides) from dose rate measurements [2]. The inventory of radioactive lightning conductors was updated. Relevant information about some models of these devices was found in an IAEA radioactive lightning conductors database.

3.2.2.2. Dismantling of lightning rods and recovering the radioactive sources

A technical manual was developed with specific procedures for handling and dismantling radioactive lightning conductors and to manage the corresponding radioactive sources safely. The individual and total activities of sources contained in RLRs are relatively low, so they cannot cause high occupational exposure. However, the spread of contamination is a definite risk to be dealt with. Lightning conductors are exposed to severe atmosphere conditions: strong storms, heavy rains that may cause damage to the device and leaking on the radioactive sources after several years of use. Most devices contain alpha emitting radionuclides (^{241}Am and ^{226}Ra), so the risk of inhalation during the handling of these sources was considered.

Before handling each device, the wipe test was used to evaluate the leak tightness of radioactive sources and the existence of radioactive contamination on a surface. If the device was contaminated it was placed in plastic bags and then in appropriate containers to avoid the spread of contamination. Adequate individual safety equipment (i.e. gloves, overalls and masks) was used by the operators.

Adequate ventilation in the environment of the disused sources was provided for contamination control and to prevent intake by the personnel. The ventilation was equipped with a proper hood and HEPA filtration. The benches and walls that may have been exposed to contamination were covered with thick plastic foil.

Specific instructions were developed for dismantling each model of RLR stored in the facility and for recovering the radioactive sources. An example of dismantling operations for the RLR Helita is shown in Fig. 5. Recovered radioactive sources were placed in stainless steel capsules for further conditioning.

Once radioactive sources have been removed from the working area, the other parts of the radioactive lightning conductor were monitored to evaluate radioactive contamination. Contaminated items were placed in plastic bags and stored in 200 L drums for decontamination or for managing as solid radioactive waste.

FIG. 5. Radioactive lightning rod Helita: dismantling operations.

3.2.3. Management of ionic smoke detectors

Ionic smoke detectors contain very low activity radioactive sources, close to the exemption values established in Cuban Regulations [10]. However, due to the large number of these devices collected together and the long half-life of the sources, special attention should be paid to the safe management of these devices when become disused.

According to Cuban regulations [11], smoke detectors, once declared disused, should be managed as radioactive waste. For this reason, disused smoke detectors should be transferred to the CPHR. Over 25 000 smoke detectors have been collected by the CPHR in the past ten years and stored at the centralized waste management facility. Smoke detectors are dismantled in order to remove the radioactive sources and condition for long term storage. The rest of non-radioactive materials should be segregated (plastic, metal and electronic components) for recycling.

3.2.3.1. Inventory of smoke detectors in the storage facility

Smoke detectors have been collected from different institutions around the country. The information regarding the radionuclide contained in the source and the activity was unknown for some models of these devices. Before starting the detectors dismantling and source recovery operations, the detail inventory of smoke detectors stored in the facility was revised and updated. The relevant information was obtained from:

(a) The waste collection formularies with information provided by the users;
(b) The registry (database) of disused radioactive sources in the storage facility;
(c) Commercial catalogues from manufacturers and distributors;
(d) Labels contained on some devices.

Some measurements have been carried out, using a gamma spectrometric system, to corroborate the available information.

Thereby, 28 different models of smoke detectors have been identified from different origin. They contain between 18 and 37 kBq of ^{241}Am or between 0.37 and 37 MBq of plutonium or around 37 MBq of ^{85}Kr. This information has been updated in the corresponding registry for disused radioactive source stored in the facility.

3.2.3.2. Dismantling of smoke detectors and recovering the radioactive sources

The safe management of ionic smoke detectors involves the device dismantling and the recovering and conditioning of the associated radioactive sources for long term storage. A technical manual was developed with specific instructions for dismantling each model of smoke detector and recovering the radioactive sources. Plastic covers, electronic and metallic components are removed until the source holder is reached. The next step involves the source removal from the holder and the corresponding conditioning operations.

Examples of dismantling operations for similar types of smoke detectors: System Sensor (different models), Notifier CPX 551, EST 1551F and Ademco 4192 are shown in Fig. 6. Those devices contain an ^{241}Am radioactive source with activity less than 18.5–37 kBq.

Smoke detectors RID-I and RID-6M, of Russian origin, contain ^{238}Pu or ^{239}Pu radioactive sources type 'ADI'. These devices generally have two sources, with an individual activity of 18.5 MBq. Specific instructions for dismantling these models of smoke detectors are also included in the manual (see Fig. 7).

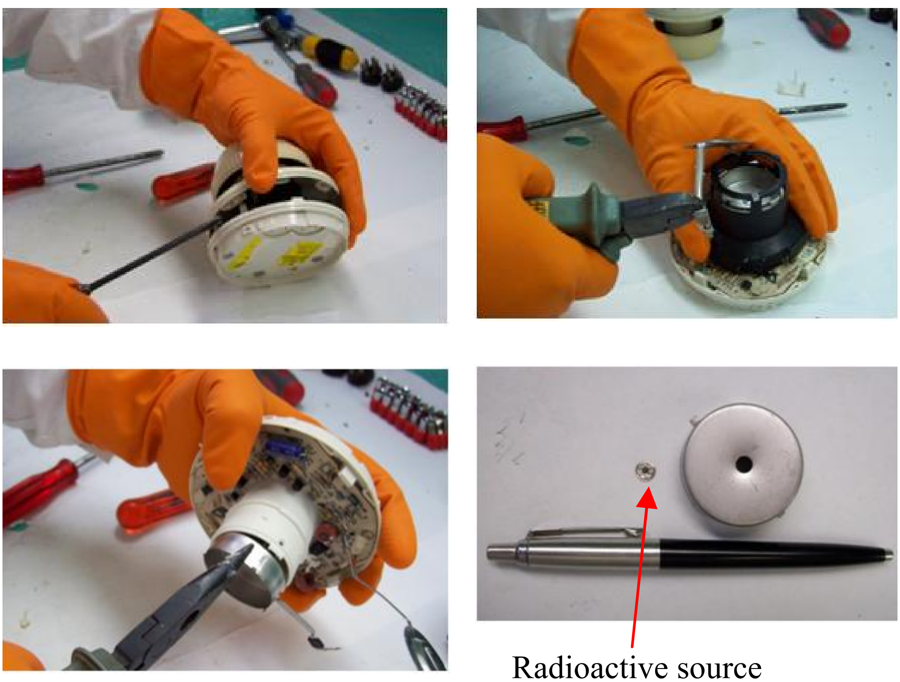

FIG. 6. Dismantling smoke detectors and recovering the ^{241}Am radioactive sources.

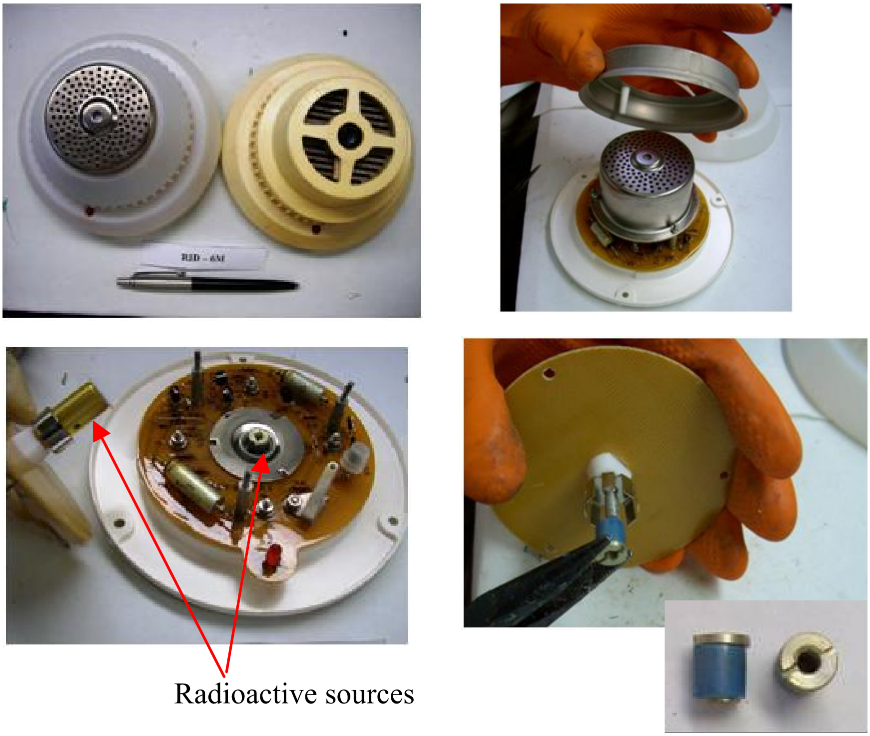

FIG. 7. Dismantling smoke detectors (RID-6M) and recovering the plutonium sources.

Recovered radioactive sources are placed in small containers, depending on the radionuclide and individual source activity. More than 5300 smoke detectors have been dismantled following this methodology. Non-radioactive components (metallic, plastic and electronic parts) are segregated and then recycled through appropriate organizations. Labels containing information regarding the radioactive sources as well as the ionizing radiation symbol are removed from these parts before taking them out from the waste management facility.

3.2.4. Conditioning of long lived radioactive sources recovered from RLRs and smoke detectors

Most RLRs and smoke detectors contain long lived radioactive sources (^{241}Am, ^{226}Ra, ^{238}Pu and ^{239}Pu), and therefore especial attention is given to the management of these sources. A methodology has been developed for conditioning of radioactive sources, consisting in encapsulation for long term storage.

The radioactive sources are placed in stainless steel capsules. Sources of the same radionuclide and individual activity are placed in a capsule. The number of sources and the total activity in the capsule are controlled and recorded. As the activity of a source is very low, the amount of sources to be placed in a capsule is limited by the source volume and the capacity of the capsule. Once loaded, the capsule is sealed by placing and welding the lid. Welded capsules are then submitted to leakage test, which is performed according to the ISO 9978 [8]. Sealed capsules are placed in a concrete lined drum for long term storage. The retrievability of the sources (sealed capsules with radioactive sources) for future disposal has carefully been considered.

3.3. Conditioning of teletherapy heads and other Category 1 and 2 sources

Teletherapy services haven been provided in Cuba for more than 50 years. The first units were received in the country during the 1960s or even before. No agreement was established at that time with the providers of the sources to return them back when became disused. These sources have to be collected from the hospitals and managed by the CPHR. Twenty-eight disused teletherapy heads are stored at the waste management facilities.

Metallic containers, according to the dimensions of the teletherapy heads, were required for conditioning of these sources. The disused teletherapy source within the working shield was lifted and positioned in the centre of the container (see Fig. 8). In order to further secure the source, two iron bars were welded on the upper part of the container. After that the container is covered with the lid and locked by screwing to prevent unintentional and unauthorized opening. Closing and locking the container concludes the conditioning process, where the teletherapy source is kept retrievable. Nevertheless, it can be stored safely with regard to irradiation, contamination and physical safety.

There are still some radioactive sources in the waste management facility that need to be conditioned. For example, neutron sources that have been stored in the facility for more than 20 years and they might lose the leaktight properties. This is planned for the near future. Adequate capsules for re-encapsulation of the sources as well as the containers for long term storage are required.

4. CONCLUSIONS

Adequate infrastructure exists in Cuba for the management of disused radioactive sources. Different procedures have been followed for conditioning different types of sources: sources of Categories 1 and 2: sources of Categories 3–5 containing long lived radionuclides; and sources of Categories 3–5 containing

FIG. 8. Conditioning of disused teletherapy heads.

short lived radionuclides. Conditioning process guaranties the safety and security of the radioactive sources during long term storage.

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SAFE AND SECURE MANAGEMENT OF SEALED RADIOACTIVE SOURCES IN GHANA

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Abstract

Radioactive sources have been in use in Ghana over the last six decades in various applications in different sectors — namely medicine, agriculture, industry, research and teaching. The Radiation Protection Board is the national regulatory authority in Ghana on radiation issues. The National Radioactive Management Centre is the only centre authorized to carry out safe management of all radioactive waste materials generated in the country. It operates a centralized radioactive waste processing and storage facility. The inventory of radioactive waste materials in storage is made up of mainly Category 3–5 disused sealed sources, which consist of density and thickness gauges, conditioned radium sources as well as smoke detectors. There are a few high activity sources also in storage. As part of long term management plan for these sources, the Government of Ghana has opted for the borehole disposal concept developed in South Africa as an end point for the disused sealed radioactive sources.

1. INTRODUCTION

The use of radioactive materials in Ghana started in 1952 at the University College of the Gold Coast (now University of Ghana) with the application of radiostrontium on monkeys [1]. The success of the experiments led to the general awareness of the numerous economic benefits to be derived from peaceful application of radioactive materials. Currently, radioactive materials are being used for diagnostic and therapeutic procedures in medicine, sterilization of medical products, industrial radiography, use of nuclear gauges in the mining, road construction, exploration for oil and minerals, manufacturing industries and consumer products. Food irradiation for shelf life extension, preservation and disinfestations are among other applications of radioactive materials in Ghana. Radioactive materials are also being employed for research activities in institutions of higher learning. Most of the radioactive materials are in the form of sealed radioactive sources (SRSs). They contain radionuclides such as ^{241}Am, ^{60}Co, ^{137}Cs, ^{3}H, ^{90}Sr and also americium in association with beryllium.

The use of SRSs is one of the major contributors to accidents associated with peaceful application of radiation related technologies. The majority of SRSs are small in physical size in the range of a few centimetres and contain very high concentration of radionuclides that range from kilobecquerels to petabecquerels. They can get easily become lost or stolen.

When these radioactive sources reach the end of their useful lives or are no longer needed for their initial intended use, they are taken out of service. They are then referred to as disused sealed radioactive sources (DSRSs). Such sources are still radioactive and require safe and secure management to prevent any hazard to human health and the environment. The spread of as little as microgram quantities of its contents into the environment can generate significant risk to humans and the environment. Improper management of these beneficial sources has contributed to several incidents/accidents around the world that resulted in serious injuries, death and extensive contamination of the environment [2]. The cost of decontamination is very high. They also present security concerns as these sources can be stolen and their radioactive materials used in radiological dispersion devices (dirty bombs) for acts of terrorism.

To ensure the safety and security of radioactive sources, it is necessary to exercise control over the sources during its entire lifetime and to safely dispose of it or have it decayed to exemption level. This requires an effective national management system. The IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [3] encourages radioactive source manufacturing States to establish schemes for re-importation of their sources. Unfortunately, there are many old DSRSs that cannot be returned to their manufacturing States. These may be due to reasons such as: the sources being too expensive to ship, the source manufacturers not being traceable; or the loss of the special form certificate.

In this paper, the national framework for management of radioactive sources in Ghana is discussed. Activities for implementation of the borehole disposal concept (BDC) for sealed sources developed by the South African Nuclear Energy Corporation (Necsa) under an IAEA regional technical cooperation for disposal of our DSRSs are also highlighted.

2. REGULATORY CONTROL

The Radiation Protection Board (RPB) was established in 1993 under legislative instrument LI 1559 as the national regulatory authority on radiation issues in Ghana [4]. It has the mandated to license, register, authorize and inspect radiation sources as well as enforce code of practices for the purposes of radiation safety in Ghana [5]. Before the establishment of the RPB, there was no legal framework enforcing registration, licensing and safe handling of radiation sources. Therefore, following the establishment of the RPB, priorities were set to gain control over radiation sources that were in the country before the establishment of the RPB. With the assistance of the IAEA, the RPB was able to identify some institutions and industries which were likely to possess radioactive sources. Questionnaires were developed and sent to the identified institutions and industries. The answers to the questionnaire led to retrieval of some disused sources and registration of the institutions using radioactive materials.

The RPB uses the IAEA registration software called the Regulatory Authority Information System (RAIS) to record radioactive materials imported into and exported out of the country. The RPB liaises with the Customs Excise and Prevention Services, the National Security Council, the Bureau of National Investigation, the Standard Board and the Environmental Protection Agency to monitor and prevent illegal acquisition of radioactive materials, thus protecting the citizens of Ghana from radiation exposure. Representatives of these state organizations are trained in radiation detection and protection procedures.

3. RADIOACTIVE WASTE MANAGEMENT

The National Radioactive Waste Management Centre (NRWMC) of the Ghana Atomic Energy Commission (GAEC) is only the authorized radioactive waste management centre in Ghana for management of radioactive waste materials. The NRWMC operates a centralized radioactive waste processing and storage facility (see Fig. 1) that has physical protection systems (CCTV cameras, motion detectors and alarm systems) to ensure the security of the radioactive waste materials in the facility, which make it suitable for the management of radioactive waste. The radioactive sources are stored in locked metal cages (see Fig. 2), which enhances the security of the radioactive sources.

FIG. 1. Centralized waste processing and storage facility.

FIG. 2. Physical protection systems in the storage facility and storage cages for the radioactive waste materials.

With the collaboration of the RPB, staff of the NRWMC have collected and transported a number of DSRSs from users for management at the central radioactive waste processing and storage facility. Transportation of the sources from the waste generation site is done in accordance with the Radiation Protection and Safety Guide No. GRPB-G:2000, Safe Transport of Radioactive Materials [6]. The NRWMC notifies the RPB in writing of the transfer of the sources to the NRWMC facility to enable the RPB to update its RAIS database accordingly.

The NRWMC employs the IAEA developed software, Radioactive Waste Management Registry (RWMR v1.06) for its radioactive waste tracking system. The inventory of radioactive materials stored in the facility include various forms of Category 3–5 sources, which include density and thickness gauges, smoke detectors, radiography sources, conditioned radium needles, food irradiators and teletherapy heads. The NRWMC undertakes regular monitoring of radiation levels within and around its facility as part of compliance with safety provisions.

The radioactive waste management system practiced in Ghana is storage. Decay storage is suitable for short lived low activity disused sources that will decay to clearance levels within one year from the time of its generation. (e.g. ^{192}Ir, half-life 74 days). However, storage of long lived radionuclides, such as ^{241}Am, requires a period of 4322 years for its activity to be reduced by a factor of 1000, while ^{226}Ra requires 16 000 years (see Fig. 3). The IAEA Code of Conduct [3] encourages source manufacturing States to establish schemes for re-importation of their sources. Unfortunately, most of the disused radioactive sources in storage are not covered by this agreement, so they have to be managed in Ghana. These sources therefore have to be safely and securely managed in Ghana.

Long term storage requires financial resources to maintain the storage facility and personnel. Depending on environmental conditions, the stored radioactive sources may deteriorate and place undue burden on the future generation which does not comply with the objective of radioactive waste management. There is therefore the need for a repository taking into consideration the quantity of waste generated in the country. This problem was raised by African Member States of the IAEA in 1995, and in response, the IAEA contracted Necsa to develop

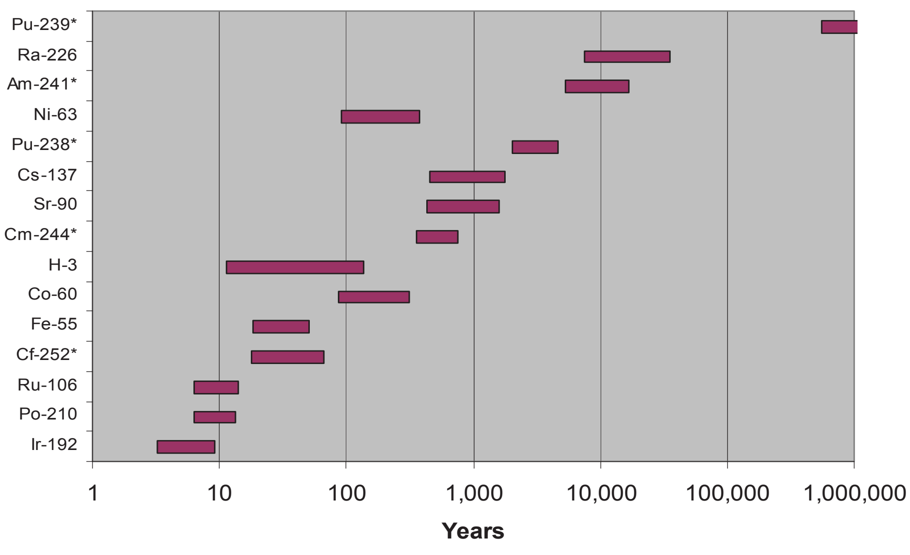

FIG. 3. Time required for a sealed source to decay to exemption levels.

the borehole disposal of disused sealed sources (BOSS) concept as part of the African regional project. The concept was developed in 2001 and has undergone international peer review.

Given that disposal is the only sustainable option and considering the quantity of sources in storage, the Government of Ghana through GAEC expressed interest in the use of the BDC as the end point option for the management of DSRSs in storage.

4. THE BOREHOLE DISPOSAL CONCEPT

The BOSS concept comprises a borehole drilled to a depth of about 100 m and 0.25 m in diameter (see Fig. 4). The borehole is lined with mild steel or high density polyethylene tubing with concrete pumped into the gap between the lining and the host rock. The tubing is to define the disposal volume and aid the package emplacement process. To ensure that the disposal volume is dry during the operational period, a bottom plug of concrete is provided.

The DSRS to be disposed is sealed in a 3 mm thick 304 stainless steel capsule which is 110 mm long and 22 mm in diameter and the lid welded. The capsule is then placed in the hole in a pre-cast concrete in a 316 stainless steel container which is 114 mm in diameter and 250 mm long. The container also has a welded lid (see Fig. 5). Leak testing of both the capsule and container

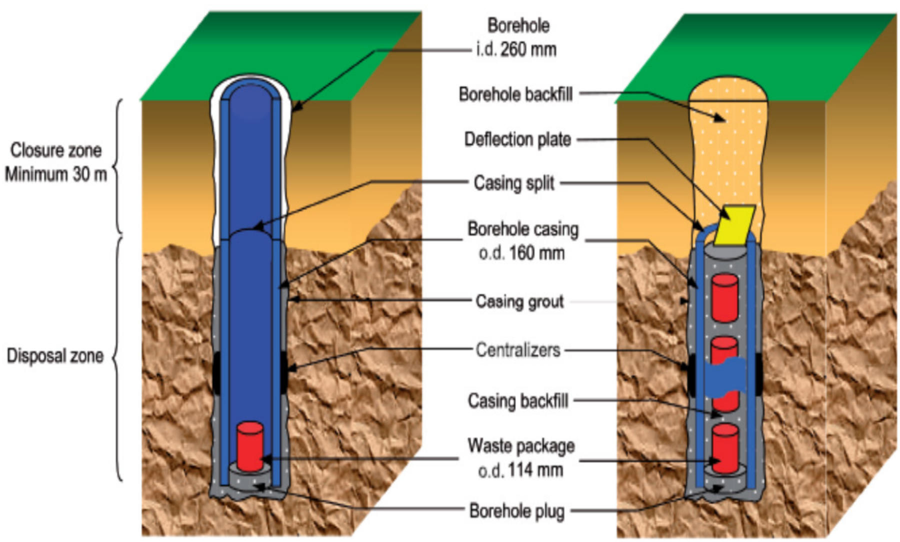

FIG. 4. Schematic representation of the borehole disposal concept.

FIG. 5. Source capsule and disposal container.

guarantees that the radionuclides are safely contained. The disposal containers will be disposed spaced 1 m apart using cement backfill.

The topmost disposal package will be 30 m below ground level. Fifty waste packages can be disposed of in a 100 m borehole. The limiting factor for the number of waste packages will be the waste inventory and the site characteristics. With all the packages in place, the section of borehole lining above the topmost package is removed. A steel deflection plate is placed above the topmost package to prevent inadvertent drilling into the disposal zone and the (now unlined) top of the borehole is filled with concrete to within 2 m of the surface (see Fig. 4). The final 2 m is filled with native soil. The intention is that while the general location of the borehole may be well known, its precise location (to within a few metres) will not. The aim is to improve security by making the borehole difficult to locate without specialized knowledge and equipment.

5. SAFETY ASPECTS

The safety concept of a disposal system is aimed at isolating the waste from the accessible environment, controlling the releases of radionuclides reaching into the accessible environment, and mitigating the consequences of any unacceptable releases that may reach the accessible environment. The waste package plays a significant safety role in the BDC. Its primary function as an engineered barrier provides complete confinement of the radionuclides in the disposed source for a predetermined period, after which the waste package is likely to degrade allowing direct contact of the sources with the waste form and groundwater. The waste form controls the release of radionuclides for a further period. The secondary function of the waste package is to facilitate conditioning, handling, transportation and disposal of the DSRSs.

The capsule and container material used for the waste package are 304 and 316 austenitic stainless steel respectively. Stainless steel is more resistant to corrosion than carbon steel and passivated by high pH conditions. Electrochemical measurement of the uniform corrosion of 316 austenitic stainless steel at ambient temperature under aerobic neutral to alkaline conditions indicates a rate of about 0.02 μm/year [7]. The anaerobic rate appears to be similar [8]. With a total thickness of stainless steel of 9 mm (capsule + container) corroding from one side only, requires a time period of 400 000 years for total penetration. Waste package integrity maintained for such sufficiently long period will allow the activity of the radionuclides (e.g. ^{226}Ra) to decay to negligible levels.

The cement waste form provides a barrier between the capsule and aggressive chemicals (primarily chloride) that may initiate corrosion on the capsule. Localized corrosion of stainless steel could occur when the prevailing environmental conditions allow an acidic solution to form locally. Conditions that promote localized corrosion include the presence of aggressive anions, especially chloride, elevated temperatures and crevices or surface roughness. Localized corrosion does not occur under anaerobic conditions. The presence of large quantities of concrete, which is a very alkaline material, tends to inhibit localized corrosion. For instance, in 316 stainless steel at room temperature, a chloride concentration of about 1000 ppm may be enough to initiate localized corrosion at pH 6–7 [9], whereas at pH 13, the chloride level needs to be more than ten times higher [10]. Secondly, cement provides chemical buffering of the waste disposal system, which may intrinsically limit the release of the radionuclides. Four hundred thousand years would be insufficient to contain the very long lived progeny of ^{241}Am and ^{239}Pu, but their mobility in cement is very low. Thus, concrete provides a physical and chemical barrier through which leached radionuclides must pass before release into the surroundings.

The geosphere is used as a natural barrier in the overall disposal system design. Therefore, the BOSS concept comprises a system of natural and engineered barriers to prevent or control the release of the radioactive waste from the repository, and to prevent the subsequent movement of radionuclides from the repository through the geosphere and biosphere, to eventually reach humans. The disposal depth of 30 m is sufficient to avoid human intrusion by excavation. A Nuclear Energy Agency expert report on near surface disposal states that 20 m is the maximum depth of excavation associated with house construction [11]. Deeper excavation from mining, tunnels for road and railway construction and exploratory drilling will be eliminated during the siting process. The steel deflection plate at the top of the disposal zone will eliminate drilling into the waste packages.

6. IMPLEMENTATION OF THE BOREHOLE DISPOSAL CONCEPT IN GHANA

Implementation of the BDC in Ghana began in 2006 when the Government of Ghana through GAEC expressed its willingness to exploit the BDC developed in South Africa under the IAEA technical cooperation project. Based on the recommendations of a team of experts recruited by the IAEA who visited Ghana to assess the potential of implementing the borehole disposal project in Ghana, the project commenced. The BOSS project in Ghana has so far been implemented under two IAEA technical cooperation projects:

— Implementing the Borehole Disposal Concept Phase I (GHA/3/003)2009-2011;
— Implementing the Borehole Disposal Concept Phase II (GHA/9/006)2011-2013.

The aim of the Phase I was to identify and completely characterize a site for implementation of the borehole disposal facility in Ghana. Under the project, the following activities have been carried out: a review of national radioactive waste management regulation to include regulations on waste disposal; drafting of national radioactive waste management policy and strategy; and development of technical specifications and contract document for site investigation. Initial site characterizations including detailed geophysical investigation (seismic refraction and electrical resistivity studies) have been carried out. A preliminary safety assessment for the BDC in Ghana has been carried out using regional data with the aim of identifying the key parameters that need to be characterized at the proposed site taking into account the inventory to be disposed. The IAEA has provided training on various aspects of the BDC to staff of the NRWMC in the form of scientific visits, fellowship, expert missions as well as national and international trainings programmes.

The objective of the second phase of the project was to carry out site specific safety assessment and develop a safety case for implementation of the borehole disposal facility in Ghana. This involves carrying of geological, hydrogeological and geochemical studies on the selected site. Two investigatory boreholes have been drilled on the selected located on GAEC premises to depths of 150 m (see Fig. 6).

One of the basic requirements of the BDC is the implementation of measures that will afford the protection of human beings (e.g. workers and general public) and the wider environment as a function of time. It includes dose targets and limits for workers and the general public during operational and post-closure phases of the facility. The safety and security of the BDC will be adequately demonstrated with reasonable assurance to the regulatory authority and other relevant stakeholders.

The licensing process for the BOSS concept will therefore include:

(a) Requirements for the protection of human health;
(b) Requirements for the assessment procedure needed to ensure that safety is achieved;
(c) Technical requirements for waste acceptance, siting and site evaluation (which includes the environmental impact assessment), design, construction, operation, closure of the repository and the post-closure phase.

Licences would only be issued when the acceptable level of safety has been demonstrated with reasonable assurance in compliance with all national and international regulations. It is good practice for the licence to have sufficient flexibility to accommodate foreseen or possible changes in design, or increased knowledge. However, all design changes with significant impacts on borehole safety (e.g. changes to the waste acceptance criteria, backfill and cover, among other things) will be based on a reassessment of facility safety and be

FIG. 6. Drilled investigatory borehole for site characterization and geological logging exercise carried out during the drilling process.

implemented after the approval by the RPB. The licence also requires reporting of the waste received and disposed of at the borehole facility. This will contribute to the development and maintenance of a national inventory of radioactive waste and will ease the transfer of knowledge to the future generations.

The safety objectives during the operational period are that doses to workers and members of the public exposed as a result of operations at the disposal site are to be as low as reasonably achievable (ALARA), social and economic factors being taken into account, and are to be kept within applicable limits and constraints.

7. CONCLUSIONS

Uncontrolled and unsecured storage of SRSs pose significant radiological risk to human health and the environment. Ghana has an established regulatory authority — the RPB — supported with a legal framework to enforce the code of practices ensuring radiation safety in Ghana and a waste management organization — the NRWMC — which operates a centralized waste processing and storage facility for management of radioactive waste. Increase in use of radioactive sources in Ghana will increase the amount of disused radioactive sources generated in the country. The long storage of these sources poses nuclear risk to human health and the environment. A disposal option will provide a safe and secure management option. The BOSS concept provides a suitable disposal option. Its limits the radiological risk to present and future generation presented by long storage of disused radioactive sources. It has a low probability of human intrusion and future disruptive events due to the small footprint of the borehole. The BDC also enhances security as it makes the DSRSs not accessible for theft. The development of a borehole disposal facility in Ghana is being carried out in compliance with relevant national regulations. Safety and environmental impact assessments are being performed to demonstrate and prove that the concept is safe and the disposed sources will be secure.

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IAEA APPROACH TO OPERATIONS SOLVING PROBLEMS OF DISUSED SEALED RADIOACTIVE SOURCES IN MEMBER STATES

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Abstract

The paper explores the risks of and available methods for managing disused sealed radioactive sources (DSRSs). In addition, the IAEA's process for prioritizing projects and selecting the appropriate technical option for each Member State that requests assistance is described. Finally, the support received from many cooperating organizations and States is acknowledged, as well as the accomplishments of the Waste Technology Section source management team of the IAEA Division of Nuclear Fuel Cycle and Waste Technology working with Member States to solve problems associated with DSRSs in their countries.

1. INTRODUCTION

Since the progress recorded during the 2005 Bordeaux Conference on the Safety and Security of Radioactive Sources, many further efforts have been undertaken to improve the safety and security of sealed radioactive sources throughout their life cycle. For example, more than 750 radioisotope thermoelectric generators (RTGs) containing millions of curies have been recovered within the Russian Federation; and the US Off-Site Source Recovery Project has also recovered more than 27 000 disused sealed radioactive sources (DSRSs) comprising more than 840 000 Ci domestically and repatriated more than 2500 DSRSs from other countries [1]. In addition, source recovery and storage activities are being conducted in many IAEA Member States and source suppliers are continuing or increasing efforts to reuse and recycle DSRSs [2]. The 2012 Seoul Nuclear Security Summit further encouraged States to implement relevant IAEA documents, as well as "continued national efforts and international cooperation to recover lost, missing or stolen sources and to maintain control over disused sources" [3] (see Fig. 1).

FIG. 1. Badly corroded, high activity source containing devices from an operation in 2013.

2. BACKGROUND: DISUSED SOURCE RISK

The safety risks (and especially the consequence part of the risk equation) associated with sealed radioactive sources have been widely publicized [3–8], including in reports from accidents and incidents involving them [9–14]. Radiation emergencies involving sealed sources "can occur anywhere," [9] and many such emergencies "that resulted in the death, or serious injury to, members of the public involved dangerous orphan radioactive sources. A common scenario for such emergencies is that of a dangerous source obtained by someone who is unaware of the hazard."

Regarding security risk, international conferences including the 1998 Conference on the Safety of Radiation Sources and the Security of Radioactive Material, in Dijon, France, the 2003 Conference on Security of Radioactive Sources in Vienna, Austria, and the 2005 Conference on Safety and Security of Radioactive Sources, in Bordeaux, France, articulated concerns about the security of sealed radioactive sources and their possible misuse for malicious purposes. IAEA guidance publications acknowledge that:

> "The purpose of an *unauthorized removal* of *nuclear material* could be for use in the construction of a nuclear explosive device or for subsequent exposure or dispersal leading to harmful radiological consequences" [6] (original emphasis, footnote omitted).

Further, they express the "growing concern that terrorist or criminal groups could gain access to high activity radioactive sources and use the sources maliciously" and encourage "a balance between managing sources securely while still enabling them to be used safely by authorized personnel" [15]. The Code of Conduct on the Safety and Security of Radioactive Sources (Code of

Conduct) [5] explicitly recognizes “the need to protect individuals, society and the environment from the harmful effects of possible accidents and malicious acts involving radioactive sources,” and encourages IAEA Member States to take several measures to address both safety and security risks associated with sealed radioactive sources. More recently, the communique of the 2012 Nuclear Security Summit [3] encouraged States to secure sealed radioactive sources, adopt guidance from applicable IAEA Nuclear Security Series publications and the Code of Conduct, and:

> “establish national registers of high-activity radioactive sources ... share best practices on the management of radioactive sources, and … encourage continued national efforts and international cooperation to recover lost, missing or stolen sources and to maintain control over disused sources” [3].

Recognizing that many sealed source related accidents and incidents involve DSRSs [9] and that more fatalities have occurred during incidents involving DSRSs or sources that became disused after being lost from equipment during use, the IAEA has intensified its efforts to work with Member States to solve problems involving DSRSs and orphan sources and, where warranted, conduct operations to condition DSRSs for longer term storage, transportation and/or disposal. Since 2005, thousands of DSRSs have been recovered and safely conditioned for storage in secure national facilities in the countries in which they were recovered. In addition, numerous Category 1 and 2 sources have been repatriated to their countries of origin for safe and secure storage and/or disposal.

3. METHODS FOR MANAGING DISUSED SEALED RADIOACTIVE SOURCES

Disused sources present a special management challenge because of their high specific activity and the fact that the institutional knowledge about them is often lost, especially when such sources are stored for long periods of time at user facilities [16]. For this reason, IAEA guidance encourages States to develop national policies and strategies specifically to manage orphan, spent high activity and vulnerable radioactive sources [16, 17], which are defined as sources “for which the control is inadequate to provide assurance of long term safety and security, such that [they] could be relatively easily be acquired by unauthorized persons” [16]. This definition applies to many DSRSs, especially those stored at user facilities. Many States now reflect in their regulations that contractual arrangements for the purchase of new sources include language requiring return to manufacturers at the end of use. While this is very helpful, many regulators have realized that even such language is not a perfect solution for the following reasons:

(a) The approach does not deal with ‘legacy’ disused sources purchased prior to such regulatory requirements.
(b) Return to manufacturers may not be possible due to companies going out of business, industry consolidation, lack of suitable certified shipping containers and other factors.
(c) Even where a manufacturer is willing to accept return of a source, financing of such an activity may not be possible for the user.

Especially for Category 1 and 2 sources, the costs for return of a DSRS without purchase of a new replacement source or sources can exceed €100 000. Regulatory requirements for upfront funding of such costs can have a chilling effect on the provision of essential services such as blood irradiation and cancer treatment.

DSRS management should only be performed by licensed organizations with qualified and experienced staff and suitable facilities, and only with regulatory approval [17]. For higher category DSRSs, management options include the following [17, 18]:

— Return to supplier.
— Transfer of existing DSRSs from user facilities to centralized long term storage.
— Recycling or reuse of radioactive sources wherever possible.
— Temporary storage (which may not satisfy the safety, infrastructure and control requirements of extended storage), such that “efforts should be made to transfer the [spent high activity radioactive sources] to an interim (maybe central) storage facility within a reasonable time” [17].
— Interim storage under proper regulatory requirements and with adequate infrastructure. This can be done in wet storage in pools or dry storage in shielded casks [18].
— Disposal in near surface disposal repositories (though many do not accept DSRSs), deep underground disposal or boreholes. Deep geologic disposal is a safe solution for all sources but costs are prohibitive, especially for most States with small inventories. Borehole disposal has been assessed as safe, technically feasible and cost effective by peer review [19, 20].

If storage is required, sources should be conditioned to produce a waste package acceptable for handling, extended storage, transport (if needed) and disposal, with minimal repackaging. This requires specialized infrastructure and expertise, as discussed below.

For smaller DSRSs, such as Category 3–5 sources, management options are similar, although the possibility of some options such as recycling are more limited. In addition, decay storage wherein shorter lived sources are stored for several half-lives until they meet national criteria for disposal is an option for some types of Category 3–5 sources [21], generally for isotopes with a half-life of up to 100 days. Storage and disposal can be just as problematic for these sources, due to the extremely long half-life of some commonly used isotopes, such as ^{241}Am and ^{226}Ra, which require that security and safety arrangements and procedures be sustained over long periods of time. Such arrangements may include electronic monitoring, alarm response, container inspections, maintenance of environmental conditions (to preclude corrosion and other extended storage problems), radiation control programmes to perform regular monitoring, quality assurance programmes, maintenance of container and source specific data, and numerous other measures. The IAEA initially focused on ^{226}Ra DSRSs, which cause problems due to their greater propensity for gas generation, subsequent breach of welds, leaking, and possible exposure to personnel and contamination of storage areas. The IAEA has developed specialized procedures for packaging such sources and supported regional teams conducting conditioning operations in many States (see Fig. 2).

4. PRIORITIZATION AND SELECTION OF TECHNICAL OPTIONS

The IAEA’s approach for providing the kind of assistance mentioned previously varies depending on many factors, but an early decision point is the source categorization. As described in IAEA Safety Standards Series

FIG. 2. Disused Category 3–5 sources in storage in Eastern Europe in 2012.

No. RS-G-1.9, Categorization of Radioactive Sources [22], Category 1 and 2 sources can cause permanent injury to a person in contact with them for a short and can be fatal if unshielded. They are also of concern from a security perspective due to the possibility of deliberate misuse or dispersion. Category 3 sources, while still considered 'dangerous', are unlikely to be fatal unless a longer exposure time occurs. Category 4–5 sources, while not considered individually dangerous or fatal, can cause injuries to humans, especially when aggregated. The procedures and equipment needed to safely handle these different categories are quite different. For example, Category 3–5 sources can generally be handled using portable shielding and appropriate radiological monitoring, whereas Category 1 and 2 sources need to be managed in a hot cell or other engineered configuration (such as pools) that provides very robust shielding. The need for specialized equipment and storage containers not available in many countries impacts how the sources can be managed.

The IAEA uses a prioritization scheme to inform decisions about providing direct assistance to Member States in managing Category 1 and 2 DSRSs. This is necessary because the needs of Member States exceed the funding (through all mechanisms) available to IAEA to address them. The prioritization scheme considers the security situation in the State, sustainability of possible options and cost. The security situation is perhaps the most difficult factor to characterize, but many factors are considered, including total activity of DSRSs present, isotopes involved, potential threats such as governmental instability or armed insurgent groups, infrastructural maturity such as existence and effectiveness of regulations and national storage facilities, and political commitment of the State to the Code of Conduct. Removal to the country of origin is considered to be the most sustainable option, regardless of the security situation in the State, whereas conditioned and unconditioned long term storage are considered progressively less sustainable. The length of time for which storage will be required is often not known and may be several decades or longer, during which time safety and security features need to be sustained; this can be very difficult, especially in States that do not have nuclear power infrastructure. However, the IAEA has chosen the option of conditioning for longer term storage in some cases where Member States have robust institutional control systems for DSRSs and the amount of funding available precludes execution of the most sustainable option. Disposal in a licensed facility would also be considered among the most sustainable assistance options, but it is not yet available in most of the States in which IAEA is providing direct assistance.

Cost also needs to be considered in the prioritization of work, given the funding constraints. The availability and amount of funding is an important and sometimes limiting factor.

It should be noted that use of the prioritization scheme outlined above is possible only where Member States have elected to provide data on their DSRS inventories to the IAEA. This is sometimes done during training courses and regional meetings associated with technical cooperation projects; such information is also collected during fact finding missions conducted by agency staff and contracted experts. Some manufacturers have provided data about the locations to which sealed sources were provided in the past, as well as technical details about the source and devices models and quantities provided. However, most States have received DSRSs from more than one manufacturer, so at best such information presents an incomplete picture. An effort is underway to estimate sealed source inventories in countries based on a statistical methodology, which could help with prioritization of States for which little inventory information is otherwise available. However, that effort will not provide the kind of source specific information that is needed for operational planning. The assistance of the manufacturing community in identifying potential needs among the former recipients of their sources is therefore also very important.

Technical options for the management of Category 1 and 2 sources include reuse and recycling, repatriation to the country of origin, storage and disposal. Repatriation can be accomplished by overpacking the shielded portion of the device containing the source into a certified transport package, transferring the bare source to a transport package certified for non-special form radioactive material, or transferring the bare source to a transport package certified for special form radioactive material if it meets, or can be repackaged to meet, special form requirements. Conditioning of the source to produce a waste package suitable for transportation and/or long term storage requires the use of specialized equipment such as a hot cell. Establishing a safe and secure storage facility or upgrading an existing facility for long term storage of sources in their original devices is also a possibility, but may create other problems over the long term. It should be noted that disposal is not currently an option in most IAEA Member States, especially for Category 1 and 2 sources, even where low level radioactive waste disposal facilities exist.

To meet the need for specialized equipment for the conditioning of Category 1 and 2 DSRSs, the IAEA funded the design of a mobile hot cell (MHC), technology that was conceived by the IAEA and developed by the South African Nuclear Energy Corporation, under contract to the IAEA. Since 2009, the MHC has been used to condition high activity DSRSs from devices in the field in four countries, with plans for further missions underway (see Fig. 3). The MHC was designed for use with gamma emitting sources up to the equivalent of 37 TBq of ^{60}Co, but it has been demonstrated to meet all necessary safety requirements during a functional test with a cobalt source of more than 74 TBq [23]. Other

FIG. 3. Recent hot cell operation in Asia with removal of DSRS into a long term storage shield.

solutions are also being pursued, including borehole disposal of DSRS under certain conditions.

The technical options available for management of Category 3–5 sources are essentially the same but technical and infrastructural requirements are different. Also, as previously mentioned, decay storage for shorter half-lived isotopes is possible. IAEA-TECDOC-1145, Handling, Conditioning and Storage of Spent Sealed Radioactive Sources [21], states “3–5 years is a reasonable time for application of storage for decay option” and “disposal of decayed spent … should not be made until it is confirmed that the residual activity to be released to the environment meets clearance levels established by the regulatory body.” Recycling is generally less available for Category 3–5 sources, with some exceptions for commercially ‘valuable’ isotopes such as ^{241}Am.

Options for retrievably conditioning Category 3–5 sources when they are present in gauges or other equipment, which is often the case, include the following: emplacement of the whole devices in concrete lined drums or other robust containers with adequate shielding to meet facility container dose limits; or removal of sources from such devices and conditioning of the bare sources in shielded containers. While the latter approach has the advantage of greatly reducing the volume of material to be stored, due to the possibility of breaching a source and causing a contamination event with resultant dose to personnel, the removal of bare sources from gauges requires special expertise and monitoring, as well as a thorough knowledge of the design of all gauges to be disassembled [21]. Therefore, unless a State has a large number of gauges and appropriate infrastructure (both in terms of facilities and knowledgeable personnel), removal of bare sources for conditioning is not a preferred option.

5. SUPPORT FROM COOPERATING ORGANIZATIONS AND STATES FOR DISUSED SEALED RADIOACTIVE SOURCE MANAGEMENT

The IAEA is supported in its efforts to provide direct assistance to States in managing their disused sealed sources in a variety of ways. First, extrabudgetary contributions to the Nuclear Security Fund from the European Union, Canada, France, Germany and the United States of America have supported both conditioning and removal projects for Category 1 and 2 sources and aggregations, as well as the salaries of technical experts who manage the projects. Second, many States provide technical experts to support fact finding missions and training courses and develop technical guidance documents. Finally, source conditioning projects, especially for Category 3–5 DSRS, are supported through the Technical Cooperation Fund for specific interregional, regional and even national projects on the subjects of radioactive waste and sealed source management and infrastructure.

6. WORKING WITH MEMBER STATES: ACCOMPLISHMENTS OF THE WASTE TECHNOLOGY SECTION SOURCE MANAGEMENT TEAM OF THE IAEA DIVISION OF NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY

Since the Bordeaux Conference [18], the source management team in Waste Technology Section of the IAEA Division of Nuclear Fuel Cycle and Waste Technology (NEFW-WTS) has recovered and/or conditioned for long term storage more than 8500 DSRSs in relatively secure national facilities. In addition, approximately 80 Category 1 and 2 sources have been removed from developing countries for either repatriation or recycling. In the case of repatriation, such sources undergo secure storage and/or eventual disposal. This work depends both on extrabudgetary donations and on the willingness of the countries of origin to allow repatriation of DSRSs and have infrastructure in place for their proper management. Without those two necessary conditions, this work could not continue.

Many Member States have also made important contributions of their own to improving the management of disused sealed sources. Increasingly, States are not only making political commitments to implement the Code of Conduct and associated import/export guidance, but also developing national strategies for such management and properly training and equipping dedicated staff for safe and secure management of sealed radioactive sources. For example, during a recent regional meeting for a technical cooperation project in Africa, State counterpart presentations described the existence of storage facilities for disused sources in 40% of the participating States. The international community often supports such efforts both bilaterally and through donations to the IAEA.

In addition to conducting operations, NEFW-WTS has produced the following technical reports:

- IAEA-TECDOC-1690, Review of Sealed Source Designs and Manufacturing Techniques Affecting Disused Source Management [24];
- IAEA Nuclear Energy Series No. NW-T-1.17, Locating and Characterizing Disused Sealed Radioactive Sources in Historical Waste [25];
- Technical Reports Series No. 436, Disposal Options for Disused Radioactive Sources [26].

The source management team solicits input from Member States about technical issues for which guidance may be helpful and is currently working on guidance documents for the proper management of disused sealed sources, neutron sources, lightning conductor sources/installations, and the decommissioning of gamma irradiation facilities. Finally, NEFW-WTS continues to maintain and improve the International Catalogue of Sealed Radioactive Sources and Devices — an on-line searchable database of information about sealed source and source containing devices models, manufacturers and containers.[1]

7. CONCLUSIONS

The safety and security risks posed by sealed radioactive sources are well known, in spite of their ubiquitous beneficial use, especially when such sources become disused. While significant progress has been made by States and the IAEA towards improving the management of disused sealed sources since the 2005 Bordeaux Conference, more work remains to be done. The IAEA has developed and implemented a prioritized approach for providing direct assistance to States in managing their DSRSs and will continue this work as long as both donor and recipient Member States support this important activity.

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SAFETY OF THE 'HISTORICAL' SPENT RADIOACTIVE SOURCES
The international technical assistance implementation results in Ukraine

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Abstract

During 2009–2013, international technical assistance projects aimed to solve the problem of security of spent radioactive sources were successful implemented. These include the Decommissioning of Irradiators and Ensuring Secure Storage of Disused Radioactive Sources, which is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, and Improving Security of Disused Radioactive Sources in Ukraine, which is financially supported by the United States Department of Energy. These projects include conducting a full range of works with radioactive sources, namely: removing radioactive sources from irradiators and from the bankrupt companies; placing radioactive sources in the appropriate containers; survey (check for tightness) and identification of sources; transportation of containers with sources to the specialized enterprise for radioactive waste management for future safe and secure storage; and receiving and placement of containers with radioactive sources in storages of specialized enterprises.

1. INTRODUCTION

In Ukraine, as in most countries, there is the issue of ensuring security of spent radioactive sources, which were used in enterprises and scientific organizations. It primarily concerns the high activity spent radioactive sources which were used in the powerful irradiator scientific institutions of Ukraine.

The difficult financial situation of enterprises and scientific establishments led to a significant reduction level of radiation safety and security of spent radioactive sources. This situation has increased the risk of radiation accidents and also the use of spent radioactive sources with criminal intentions.

2. DESCRIPTION OF SOLVING THE PROBLEM

In 2006, the State Programme on Safe Storage of Spent High Activity Sources of Ionizing Radiation was developed and approved by the Cabinet of Ministers of Ukraine. The main goal of the State programme was providing continuous long term functioning of infrastructure for the safe treatment and storage of spent radioactive sources. This programme was only partially funded by the State budget. Therefore, the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) and the Ministry of Emergency Situations of Ukraine were constantly working to apply international assistance to the solution.

Significant result of these efforts was the organization and successful implementation in Ukraine during the 2009–2013 international technical assistance projects aimed to solve the problem of security of spent radioactive sources. These are:

— Decommissioning of Irradiators and Ensuring Secure Storage of Spent Radioactive Sources, which is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety;
— Improving Security of Spent Radioactive Sources in Ukraine, which is financially supported by the US Department of Energy.

These projects include conducting a full range of works with spent radioactive sources:

(a) Removing them from irradiators and from the bankrupt companies.
(b) Placing them in the appropriate containers.
(c) Survey (check for tightness) and identification of sources.
(d) Transportation of containers with sources to the specialized enterprise for:
   — Radioactive waste management for future safe and secure storage;
   — Receiving and placement of containers with spent radioactive sources in storages of specialized enterprises.

All work on projects were carried out by specialized enterprises that have the necessary licences and permits. Monitoring of compliance with the rules, regulations and standards for radiation safety at performance of works carried out by SNRIU State inspectors. The work was performed in accordance with specially developed technology of spent radioactive source retrieval, which received positive conclusion of state expertise of nuclear and radiation safety, using certified equipment and containers.

3. RESULTS OF THE PROJECTS

3.1. Decommissioning of Irradiators and Ensuring Secure Storage of Spent Radioactive Sources

(a) 2009: From the bankrupt companies in different regions of Ukraine 7184 of the spent radioactive sources of Categories 2 and 3 of different radionuclide composition with a total activity about 1.18×10^{14} Bq were gathered. The further secure storage of collected spent radioactive sources is carried out in the storages of specialized enterprises.

(b) 2010: Technology to retrieve spent radioactive sources from irradiators was developed and containers for discharge systems were manufactured.

(c) 2011: The installation for an irradiation 'researcher' of the Institute of Biology of the Southern Seas (Sevastopol) was discharged. Twenty-seven spent radioactive source type GSs 7.029.3, with a total activity of 5×10^{13} Bq, were retrieved. Work on discharge of the installation for irradiation 'researcher" of the Institute of Cell Biology and Genetic Engineering (Kyiv) were carried out. Twelve spent radioactive source type GIK-7-1, with a total activity of 2.7×10^{12} Bq, were retrieved.

(d) 2012: The installation for irradiation of the State enterprise for radiation processing of materials 'RADMA' (Kyiv) was discharged. One hundred and eighty spent radioactive source type GIK-7-4, VII, with a total activity of 3.7×10^{14} Bq were retrieved.

(e) 2013: Work continued on the spent radioactive source removal from bankrupt enterprises in different regions of Ukraine. The plan was to remove 3313 spent radioactive sources of different radionuclide composition with total activity of 2.84×10^{13} Bq.

3.2. Project Improving Security of Spent Radioactive Sources in Ukraine

In 2010, work on discharging the installation for irradiation IGUR-1 of the Institute of Experimental Pathology, Oncology and Radiobiology, Kyiv, was carried out. Eight spent radioactive source type GSs 7.029.2 with total activity of 3.08×10^{14} Bq were removed. The spent radioactive sources were transported to a specialized enterprise for storage. Work on the spent radioactive source removal from storage and facilities of the enterprise Electron Gas, Zheltye Vody, was done. A total of 3973 spent radioactive sources with summary activity of around 1.9×10^{14} Bq were removed. Currently, the spent radioactive sources are located in the storages of the specialized enterprise.

In 2013, the planned to completion of works on discharge the installation for irradiation of the Institute of Physics of the National Academy of Sciences of Ukraine, Kiev. It is required to retrieve 58 spent radioactive source type GIK-7-4 with a total activity 2.0×10^{14} Bq. A general contractor carried out refinement of technology, manufacture and certification tests required for equipment and containers.

4. CONCLUSION

The success of these projects over the period 2009–2013 provided for the safety and security of 14 755 spent radioactive sources with different radionuclide composition of the total activity of 1.27×10^{15} Bq and practically solved the problem of decommissioning powerful irradiators scientific institutions of Ukraine, which are not used.

STATUS OF THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES IN PORTUGAL

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Abstract

In Portugal, radioactive sources are used in the medical sector, in a multitude of industrial applications and for research and education purposes. The vast majority of the existing radioactive waste falls in the categories of low or intermediate level waste. The Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources was transposed to the Portuguese legislative framework by Decree-Law No. 38/2007, which assigned the former Nuclear and Technological Institute (ITN, Instituto Tecnológico e Nuclear), which was integrated into the Higher Technical Institute (Instituto Superior Técnico) in 2012, the responsibility for the licencing and control of radioactive sources in the country. Other decree-laws also assigned to the former ITN specific responsibilities in the collection, segregation, conditioning and storage of radioactive waste. Article 4 of the Decree-Law No. 38/2007 deals with the authorization of the ownership, transport and transfer of radioactive sources and equipment incorporating radioactive sources and stipulates that in order to get the authorization the applicant must provide a cautionary fee amounting to 10% (or to 5%, if the source is incorporated in an equipment) of the cost of the radioactive source. In the paper, it is shortly described the impact of this measure in the proper use and management of disused and spent sealed radioactive sources in the country.

1. INTRODUCTION

Portugal has no nuclear power plants but a pool type research reactor, the Portuguese Research Reactor (RPI, Reactor Português de Investigação) (low enriched uranium, 1 MW), located at the Technological and Nuclear Campus (CTN, Campus Tecnológico e Nuclear) of the Higher Technical Institute (IST, Instituto Superior Técnico). Its spent fuel is shipped back to the United States of America according to an agreement with the Department of Energy. The State's radioactive waste originates from the use of sealed and unsealed sources in medical, industrial, research and educational practices and the majority of the radioactive waste consists of very low, low and intermediate activity waste

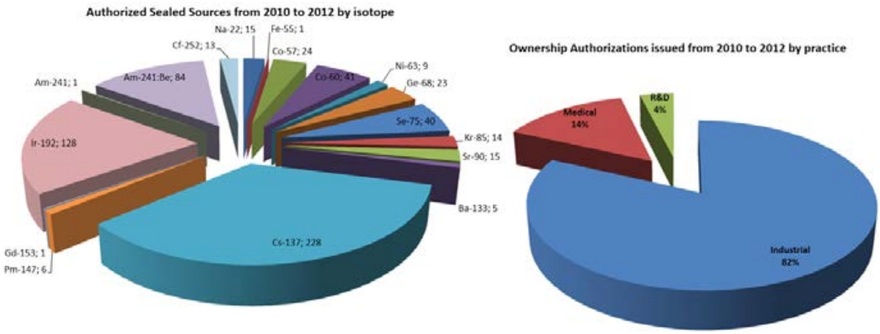

FIG. 1. Number of authorized sealed sources (left) and ownership authorizations issued by practice (right) during the period 2010–2012.

and spent sealed sources. Approximately 800 sealed sources were licensed in Portugal between 2010 and 2012, mainly for medical (14%) and industrial (82%) uses (see Fig. 1).

Disused and/or spent sources — mainly ^{60}Co and ^{137}Cs sources from industrial and medical applications as well as from research laboratories and academia, lightning rods and smoke detectors (containing ^{241}Am and ^{226}Ra sources), level indicators, nuclear gauges and other industrial equipment which contains radioactive sources — are among the ones that generated higher amounts of radioactive waste, together with contaminated material collected in scrap yards. In 2011, a total of 146 drums contained conditioned spent sealed sources were stored at the Interim Facility for the Storage of Radioactive Waste (PAIRR, Pavilhão para Armazenamento Interino de Resíduos Radioactivos), located at the CTN, while 260 sources are waiting to be dismantled.

2. RADIOACTIVE WASTE MANAGEMENT LEGAL COMPETENCE PRACTICES AT NATIONAL LEVEL

The former Nuclear and Technological Institute (ITN, Instituto Tecnológico e Nuclear), a governmental research centre, was integrated in 2012 into the Higher Technical Institute (IST, Instituto Superior Técnico), of the Technical University of Lisbon, and the competences assigned by law to the former ITN were transferred to the IST. Among other legal competences, the IST, through its Radiological Protection and Safety Unit (UPSR, Unidade de Proteção e Segurança Radiológica) has specific competences concerning the management (collection, segregation, conditioning and interim storage) of all radioactive waste produced in the country. It operates PAIRR, located on campus. It also holds competences in many other areas, such as the licensing of radioactive sealed sources, the authorization of transport of radioactive materials, collection of orphan sources and is the technical intervention authority for radiological emergencies associated to accidents during the transport of radioactive materials (Decree-Law No. 174/2002, of 25 July) and the loss of sealed sources.

3. INTERNATIONAL MECHANISMS TO CONTROL DISUSED AND SPENT SEALED RADIOACTIVE SOURCES: EU DIRECTIVES AND THE IAEA CODE OF CONDUCT

Control of sources is one of the most important aspects of the licensing system aiming at:

(a) The reduction of sources outside the regulatory system (i.e. orphan sources);
(b) The prevention of accidents/incidents, namely the melting of an orphan source with scrap metal in the smelting industry or the inadvertent and hazardous manipulation of radioactive sources;
(c) The reduction of radioactive waste. European legislation is the basis of the official ruling in the national territory.

Transfer of sealed sources between Portugal and other EU Member States follows Council Regulation (Euratom) No. 1493/93 of 8 June 1993 on shipments of radioactive substances between Member States [1], while Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS) [2], have been transposed to the Portuguese legislation as Decree-Law No. 38/2007, of 19 February.

The IAEA started a series of initiatives aimed at detecting and avoiding the international illicit trafficking of radioactive material, mainly an action plan on the safety of radioactive sources, which included the elaboration of the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [3], which was supplemented later on by the Guidance on the Import and Export of Radioactive Sources [4]. Portugal has been applying the Code of Conduct in all its practices, including licensing radioactive sources.

The IST, through the UPSR, plays a key role in Portugal in these matters dealing with the control of radioactive sealed sources and radioactive waste, from cradle to grave, having in mind the best available practices as well as the philosophy of the Code of Conduct from the IAEA.

4. ENFORCEMENT PRACTICES TOWARDS SAFETY AND SECURITY OF THE MANAGEMENT OF DISUSED AND SPENT SEALED RADIOACTIVE SOURCES

Besides legislative procedures, other important mechanisms are put in place by the IST with the overall objective of increasing awareness and responsibility in terms of management of sealed sources by the different users.

To reinforce the control of sources at national level in a joint effort with other legal authorities, the UPSR has developed a database of all licensees using sealed sources in the country and the IAEA's Regulatory Authority Information System tool is currently being implemented. The UPSR also undertakes other activities that contribute to a more responsible management of radioactive sources and aims at increasing control over sources' transboundary movements, namely:

(a) Interacts with the national stakeholders, users of radiation sources and radioactive materials, and general public, in many fields ranging from supplying services to consultancy, training and education;
(b) Provides technical advice to customs officers, namely in the framework of the Megaports initiative of the Second Line of Defense of the United States of America, implemented at the Port of Lisbon;
(c) Provides of training to users in the medical and industrial sectors, as well as education to students at the undergraduate, Master and doctoral levels at Portuguese universities;
(d) Represents the Portuguese State in Committees of the IAEA, European Union, OECD Nuclear Energy Agency, IAEA conventions and EU conventions.
(e) Contributes to the establishment of a comprehensive regulatory framework where an independent regulatory body will foresee the safety and security of radioactive waste management through the clear allocation of responsibilities, the adequacy of human and financial resources and the issuing of a national strategy and policy on spent fuel and radwaste management;
(f) Participates in the transposition/implementation of Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste [5] into national legislation.

5. CAUTIONARY FEE TO ENSURE PROPER MANAGEMENT OF DISUSED SOURCES

The Decree-Law No. 38/2007, of 19 February, which transposes HASS, establishes that for the use of radioactive sealed sources a licence must be requested to the IST prior to its possession, transport and transfer. All the licenses granted by the IST (ownership, transport, entrance and transfer, among other things) contain a description of the licensed material (radionuclides, activity and reference date, among other things) and other relevant information such as the identification of the licensee and practice or equipment where it will be used, validity and other specific conditions for the use of the sources. Additionally, under Article 4 (5) of Decree-Law No. 38/2007, of 19 February, the licensee must pay a deposit for each sealed source. Once the licensee considers that the source is no longer used for the practice for which the authorization has been granted, it should be either returned to the manufacturer or collected by the IST. Article 10 (4) of Decree-Law No. 38/2007, of 19 February, establishes that the IST will then refund the deposit made by the licensee after proof that the spent and/or disused source was returned to the manufacturer or collected by the IST. Licensees also have to deliver the annual declaration of the sources in use. Thus, the mechanism created by the deposit presents a twofold advantage:

(a) The licensee is encouraged to notify the IST once the source is no longer in use.
(b) Portugal can effectively control the licensed disused sealed sources, preventing the existence of orphan sealed sources.

This mechanism also contributes to the implementation of the Code of Conduct. The costs associated to the collection and elimination of radioactive waste by the IST, including spent sealed sources, accordingly to radionuclide and activity, are defined by the IST.

6. CONCLUSIONS

The licensing system in place obliging the applicants to pay a cautionary fee for each source they possess, accordingly the specific requirements in the law, has remarkably reduced the number of occurrences of abandon and loss of disused/spent sealed sources in the national territory and it is unique in the European Union [6]. However, the UPSR still collects on a regular basis, orphan sources found in loads of imported scrap metal detected by the radiation portal monitors of the smelting industry.

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MANAGEMENT OF EMERGENCIES AND SAFETY AND SECURITY RELEVANT EVENTS INVOLVING RADIOACTIVE SOURCES

(Session 7)

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RAPPORTEURS' SUMMARY

Session 7: Management of Emergencies and Safety and Security Relevant Events Involving Radioactive Sources

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Radiological emergencies due to the improper use or loss of control over radioactive sources have occurred and continue to occur. These emergencies can be the result of an accident, a malicious act or a natural disaster. The IAEA's Incident and Emergency Centre (IEC) is the international focal point for response to events related to radioactive sources, including provision of international assistance. For the provision of efficient assistance upon request, the IAEA has established the Response and Assistance Network, which forms an operational mechanism to provide assistance in different technical areas utilizing national capabilities registered in the network. Over the years, the IAEA has researched and published reports on a number of these incidents and emergencies. Although no reports have been published since 2005, the IEC announced that they are in the process of publishing several additional studies, with the hope that States will be able to learn lessons from them in order to avoid similar such incidents occurring again.

Several such incidents were presented and discussed in this session in an attempt to present lessons learned and recommendations for other States. On 26 December 2004, a devastating tsunami struck the Aceh area of Indonesia. It resulted in 174 500 casualties, 51 500 missing and roughly 1.5 million people displaced. Economic losses caused by this disaster exceeded US $4 billion. The tsunami also resulted in the complete destruction of a cement factory in which two ^{137}Cs gauges were housed. The significant damage caused by the tsunami hampered initial efforts by the Indonesian regulatory authority, the Nuclear Energy Regulatory Agency (BAPETEN, Badan Pengawas Tenaga Nuklir), to assess the status of these gauges. Site access was eventually gained, but the sources could not be found. Extensive efforts to search the adjacent areas were unsuccessful in finding these sources.

In April 2010, a radiation accident occurred due to dismantling of a gamma cell housing ^{60}Co radioactive source pencils by the workers in a scrap shop located in Mayapuri area of New Delhi, India. The State of Texas, United States of America, described its response to three radioactive materials incidents:

- Stolen iridium radiography camera source;
- Lost well logging source;
- Found moisture density gauge.

All of these incidents involved significant effort to assess the overall situation and to regain control over the radioactive material. In some cases, such as Indonesia, the enormous scale of the natural disaster resulted in the source loss and an inability to locate the missing sources. In the other cases, improper control over the radioactive sources caused the incident and the State had to provide an appropriate response.

Australia, Slovenia and the United Arab Emirates described efforts to develop or enhance their radiological emergency preparedness and response capacity for incidents involving radioactive sources out of regulatory control. It is critical that States develop an incident management plan which defies procedures and responsibilities for responding to an incident involving a radioactive source. The need for training and educations as well as drill and table top exercises for potential responders was highlighted as critical for success in response to a real incident.

Another important element related to emergencies involving radioactive sources and materials involving liability and payment of the costs associated with the incident. While existing liability conventions focus on large, transboundary releases from nuclear power plants, such conventions may not be suited to the more localized impacts of a radioactive sources related event. However, the financial impacts on affected licensees, facilities and the general public can potentially be significant. This concern goes far beyond cleanup costs because an incident may also result in a factory closure (lost production and loss of employee income), loss of property or homes and even medical care. Without an agreed liability regime in place, the burden of cost falls on the affected entities and the State. It was suggested that either an internationally agreed liability regime or a system of insurance could be implemented. For that purpose, some discussions could be initiated inside the IAEA, involving in particular and where necessary the International Expert Group on Nuclear Liability (INLEX) on possible options.

Communication with the public, both before and during an emergency is important as a means to limit potential damages from a missing source and to provide guidance on what can or should be done. Some of the incidents described occurred due to lack of information or knowledge, while others were resolved because an individual knew what to do. While significant natural disasters may create situations beyond the capacity of the affected State, proper planning and training along with the provision of proper information to the public can help to minimize the consequences from a radiological event.

The following recommendations were made to the IAEA:

(a) Continue efforts to assist States in developing their emergency planning and incident response capabilities for safety and security events involving radioactive sources.
(b) Continue to support sharing of lessons learned from actual radioactive source related events or incidents.
(c) Through existing mechanisms, assess the need for international approaches on potential legal and liability issues associated radioactive source related events or incidents, possibly through INLEX.

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IAEA'S ASSISTANCE IN EVENTS RELATED TO RADIOACTIVE SOURCES

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Abstract

Radiological emergencies due to improper use or loss of control over radioactive sources continue to occur. Arrangements are in place for notification, information exchange and providing of international assistance when capabilities of States to mitigate the consequences of such events are exceeded. IAEA's Incident and Emergency Centre is the international focal point for the providing of international assistance in events related to radioactive sources. For the provision of efficient assistance upon request, the IAEA has established the Response and Assistance Network (RANET), which forms an operational mechanism to provide assistance in different technical areas with the help of national capabilities registered in the network. The continued occurrence of these events and the experience accumulated by the IAEA and Member States in response to the events related to radiation sources underline the need to strengthen the international emergency preparedness and response framework; reinforce the emergency notification system, reporting and information sharing arrangements and capabilities; strengthen the way to cope with emergencies; and support the international assistance arrangements and capabilities by enhancing the IAEA's RANET.

While recognizing and underlining that the responsibility for response to radiological emergencies rests with the operating organization and with the State concerned, the international emergency preparedness and response framework is placing a clear role and responsibility on the IAEA and on the interagency coordinating mechanism — the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE). In the architecture of the framework, the 'nucleus' is provided by the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, while the IAEA safety standards provide the reinforced elements of the international emergency preparedness and response framework. The operational arrangements and the protocols established with Member States and international organizations give more substance to the framework and make it functional.

Universal implementation of the IAEA safety standards on emergency preparedness and response at the national level improves preparedness and response, facilitates communication in emergencies and contributes to the harmonization of national criteria for protective actions and other response actions. The IAEA Safety Standards Series No. GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency [1], jointly sponsored by the Food and Agriculture Organization of the United Nations, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization, the United Nations Office for the Co-ordination of Humanitarian Affairs and the World Health Organization, establishes the requirements for an adequate level of preparedness and response to a nuclear or radiological emergency in any State. National systems of emergency preparedness and response are utilizing requirements set in GS-R-2.

The role of the IAEA within the international emergency preparedness and response (EPR) framework is:

- To perform prompt notifications and to assure the official information exchange between the designated Contact Points in Member States and international organizations;
- To provide public information;
- To perform assessment of potential emergency consequences and prognosis of possible emergency progression;
- To coordinate the international assistance upon request of the State concerned;
- To coordinate the interagency response within the IACRNE.

In fulfilling its role, the IAEA has established the Incident and Emergency System (IES), consisting of a 24 hour a day contact point and an operational focal point for emergency preparedness and response, the Incident and Emergency Centre (IEC).

The IEC operates in three operational modes: Normal/Ready Mode, Basic Response Mode and Full Response Mode. In the Normal/Ready Mode, the IEC is the focal point for incoming messages. The following on-call specialists are available 24/7 to facilitate and coordinate a timely and adequate response:

- Emergency response manager;
- Nuclear installation specialist;
- Radiation safety specialist;
- Nuclear security specialist;

— External event specialist;
— Public information officer;
— Logistics support officer.

Each incoming communicated event is assessed according to its actual or potential radiological consequences and response actions are established accordingly. Criteria for the response actions are defined in the IES operational procedures and response checklists. The on-call emergency response manager determines whether the IEC activates into Basic Response Mode or Full Response Mode.

For the provision of efficient assistance upon request, the IAEA has established the Response and Assistance Network (RANET), which forms an operational mechanism to provide assistance, upon request, in different technical areas with the help of national capabilities registered in the network. The capabilities for assistance cover specific functional areas such as radiation survey, environmental sampling and analysis, radiological assessment and advice, decontamination, medical support, dose assessment, source search and recovery, advice on emergency response actions and nuclear installation assessment and advice. The IAEA RANET mechanism has been employed in the providing of assistance upon request in a number of cases over the last years.

In 2005, the IAEA provided the coordination of medical assistance and the dose reconstruction in the radiological accident in Chile, in regard to the improper handling of an unshielded industrial radiography source. Medical treatment was provided by the French National Assistance Capabilities, registered under RANET. Similar radiological accidents occurred in 2008 in Tunisia, in 2008 in Ecuador, in 2010 in the Bolivarian Republic of Venezuela and in 2012 in Peru. In each of these cases, the RANET mechanism for the provision of international assistance proved to be effective.

The IAEA provided the coordination of assistance for source identification, dose reconstruction and source recovery missions in 2006 in the Bolivarian Republic of Venezuela, in 2008 in Benin, in 2007 and 2010 in Honduras, in 2012 in Cambodia and in 2013 in Sierra Leone. These cases were related to either orphan radioactive sources in scrap metal or medical radioactive sources out of regulatory control. RANET National Assistance Capabilities from Australia, France, Mexico and the United States of America were involved in these missions.

Based on the experience accumulated over the last years and related to these response cases, there is a need to further strengthen the international emergency preparedness and response framework. The emergency notification system, the reporting and information sharing arrangements and capabilities have to be further reinforced. All counterparts should be well aware of their responsibilities and available means to notify and exchange information. There is a need to strengthen the way to cope with emergencies through sustained response capability development and testing/exercising at national and international level. Finally, there is a need for providing continuous support to the international assistance arrangements and capabilities. This can most effectively be achieved through the utilization of IAEA's RANET in line with the principles and the technical guidance provided by the EPR–RANET 2013 publication IAEA Response and Assistance Network [2].

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LESSONS LEARNED FROM THE GREAT ACEH TSUNAMI 2004 IN ENHANCING CONTROL OF RADIOACTIVE SOURCES

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Abstract

In the aftermath of the Great Aceh Tsunami 2004, the Nuclear Energy Regulatory Agency (Badan Pengawas Tenaga Nuklir) performed challenging measures in regaining regulatory control over radioactive sources used by a licensee in the impacted area. At the time of investigation and field search, the activity was designed mainly for emergency response, source recovery, and on the safety aspect. Afterwards, nuclear security part should be reassessed also for a better improvement of regulatory body.

1. INTRODUCTION

The Great Aceh Tsunami happened on 26 December 2004 following a series of a fault rupture initiated at 07:58:53 local time (00:58:53 GMT), off the west coast of northern Sumatra, Indonesia, along the Sunda Trench subduction zone plate boundary. This triggered a devastating tsunami around much of the Indian Ocean. The epicentre (the point on the Earth's surface above which the rupture initiated) was located at 3.31°N and 95.95°E, approximately 250 km south-south-east of Banda Aceh, the capital city of the Aceh Province, in northern Sumatra. From this point, the rupture continued to expand northward for more than 1200 km, generating a massive M9.3 earthquake, the largest to have occurred since the 1964 M9.2 Alaska Earthquake and the second largest ever recorded. The largest recorded was the 1960 M9.3 Chile Earthquake [1].

In total, there were 174 500 casualties, 51 500 missing and roughly 1.5 million people displaced [1]. Direct economic loss caused by this disaster was US $2.92 billion and the indirect loss was US $1.53 billion [2].

Among the loss was a cement factory (5°27'3"N, 95°14'49"E) located near Lhok Nga town, just 150 km from the epicentre. The company's report stated that 193 employees either died or were reported missing, out of total workforce of 636 [3]. Three quarters of the plant was also destroyed, along with the port and a bridge leading to the factory. This company utilized two units of ^{137}Cs gauges, with an activity of 2 mCi and 10 mCi, when it was licensed firstly by the end of 2001.

This paper describes how the team performs response and investigation in the field, lesson learned for emergency preparedness and response, gaining regulatory control over radioactive sources, and security aspect in the aftermath of disaster.

2. FIELD INVESTIGATION

All of the people in Indonesia were focused on the victims and how to help people affected by this disaster, including Nuclear Energy Regulatory Agency (BAPETEN, Badan Pengawas Tenaga Nuklir) management and staff. Attraction came to BAPETEN once the picture of this destroyed plant appeared in a nationwide newspaper on 3 January 2005 [4]. BAPETEN then quickly prepared a response inspection to the plant due to the fact that they have been the licensee for a long time.

The response team firstly contacted the company main office in Jakarta. At that time, what the company was able to provide were some contact people in Banda Aceh. However, there was no information available regarding the existence of the two sources. The main office also did not have any information regarding the existence of two radiation protection officers (RPOs) licensed and registered in BAPETEN.

The team then called the contact people in Banda Aceh. They informed BAPETEN that they are in the process of establishing a temporary office, which would be a rented house considering that their office in that city was hardly destroyed. Furthermore, they also informed that the main road bridge, as the only access from Lhok Nga town to the factory, was also gone, and that the Indonesian Army had a plan to build a temporary bridge very soon. The closest and the only reasonable way from Banda Aceh to the factory was through Lhok Nga town.

Finally, the BAPETEN response team was able to come to Banda Aceh and the factory on 13 February 2005. Even though it had already been almost three weeks after the disaster, this was the quickest response that could possibly be made, considering the availability of the licensee staff and infrastructure to the premises.

At the initial meeting in the company's temporary office in Banda Aceh, the team found that the two RPOs were stated as "missing". An investigation was started, with a series of interviews to the available 16 staff members of the company available at the office, and then to 4 other staff members and to some army officers in the factory.

The team found that all of the field documentation related to the radioactive substances was destroyed by the tsunami. There was no report to BAPETEN stated that both unit of radioactive gauging was removed from its operational position, but some staff said that since the end of 2003 the company had not used them anymore and removed it from its original place. It can be said that nobody knew exactly where the sources were. However, the team noted some places which could be considered as the storage of both units after the removal.

Some staff stated that both units were placed in a truck container box beside storage room ST-07. Others said that both units were placed in storage room ST-07. The truck container box beside the storage room was used for electrical equipment only. A member of staff stated clearly that he was one of technician who opened the Unit-2 and placed it inside storage room ST-07. However, he had never known of the existence of Unit-1.

Verification in the plant shows that storage room ST-07 was destroyed heavily and only its floor was left. Half of the upper part of the truck container box was removed about 150 m from the storage room up to the edge of a hill. There are some mounds of ruin, sand, trees, electrical and mechanical equipment downstream of the tsunami flow.

The plant has been guarded 24 hours a day by a group of military personnel since a day after the tsunami. Under the control of military staff, there were some trucks taking soil and ruins from the plant and dropping the load to an area outside the plant close to the harbour. In few days, this area was to be used for an opening ceremony of a military project to rebuild the road from Banda Aceh to Meulaboh city. Three heavy vehicles owned by the company were now under the military control and were to be used fully for the project. It could be clearly seen that theft had also taken place in the plant areas, especially of huge cables and other valuable metals. It was also more complicated that a temporary mass funeral had occurred downstream from storage room ST-07. This burial is one of the areas of suspicion where the radioactive gauging devices were located.

The team, together with senior field staff of the company, performed a radioactive search with hand-held survey meters, including a radioactive identification detector, of possible places on the site. Two and a half days passed before the team isolated three suspicious areas of mound where the gauges were possibly located with yellow lines marked with "radiation hazard".

Follow-up actions were then discussed with the company representatives. After an explanation by the team, the representatives clearly understood the hazard of their radioactive sources. They were then asked and agreed:

- To take any necessary measures to prevent their staff and public from panicking;
- To reproduce the drawing of the gauging camera (source with the container) with required instructions and to distribute this poster to their security staff and military personnel located at the plant;
- To inform BAPETEN promptly if any of the gauging cameras (or any suspicious objects resembling the camera) were found or if there was a plan to remove the ruins or mounds from the plant for refurbishment;
- To allow BAPETEN and the IAEA team to search should there be a programme to search for the missing radioactive gauges.

Many other difficulties were also found by the team in the plant site. Even with intensive interviews to all the available employees of the company and a comprehensive filed inspection in the plant site, the team could still not locate the two radioactive sources [5]. Almost a year after this event, BAPETEN also performed the second investigation at this facility. However, the status is still the same: open [6].

3. LESSONS IDENTIFIED AND LEARNED

From the above description of disaster, BAPETEN identified a very important lesson that more attention should be given to facilities that could be affected by both natural and human induced hazards. Furthermore, from the failure to recover the missing sources, BAPETEN also learned that both safety and security could be a very big problem, and that response also cannot be easily performed, in the aftermath of a great disaster.

3.1. Emergency preparedness

In the preparedness aspect, this case also shows that it is very important for a regulatory body firstly to list and map all licensees close to the source or could be affected by natural hazards. This could enable the regulatory body to conduct better planning of their activities. Frequency of visits both for inspection and capacity building should be increased to a reasonable time, where assurance can be made that all of the radioactive sources will always be in regulatory control. Twice a year for the first three to five years of the programme might be sufficient, and at least once a year after that. Another way could be inviting all of these licensees to a special workshop or seminar, but it may be less effective since the real situation of all licensees could be different to each other and this situation is very different with the meeting room.

With the visits, the regulatory body should ensure that licensees understand the radiological risk (and then also the security threat) related to the risk gained by natural hazards. Based on that, the licensees should integrate their radiological emergency preparedness and response programme to all other (both natural and human induced) hazards. Infrastructure and functions in this emergency preparedness and response are to be developed and maintained by the licensees. Both table top and field exercise should be recommended to them, and the regulatory body may provide guideline and observation comment to enhance the quality of this exercise.

The National Nuclear Emergency Preparedness and Response Organization (OTDNN, Organisasi Tanggap Darurat Nuklir Nasional) had not yet established when the disaster happened. Following a series of national meeting starting in 2005, the OTDNN is now established in the country. In accordance with IAEA standards [7, 8], the OTDNN is comprised of the National Agency for Disaster Management agency, the police, fire brigades, the Ministry of Health, the military, the Ministry of Transport, and the Indonesian Agency for Meteorology, Climatology and Geophysics, among others. Access for radiological response to disaster area, especially in the remote one, can be relatively easier to be done with good coordination in the OTDNN.

3.2. Security of radioactive sources

BAPETEN learned that prevention measures, such as source mapping database updating, especially for licensee with numerous radioactive sources, is a very important issue, both for the licensee and the regulator side. This updating is to be done with the licensee’s reporting system and ensured by regulatory inspection. This is now become a regular practice of licensing and inspection at BAPETEN.

When a huge disaster like the Great Aceh Tsunami 2004 happens, detection measures will be extremely difficult to be maintained. Even if they work, the response might not be able to be done accordingly. Regulatory response performed by BAPETEN can be actually considered as both for nuclear security and radiological emergency, even though at that time it was mainly aimed for emergency response, source recovery and the safety aspect.

General security situation following such disaster can be chaotic and open possibilities for crime actions like theft, although the last one cannot be generalized to be always happening to every State. However, without any detection and response system it can be said that the threat level will be very high.

As all of us are very well aware, one of the national detection strategy in nuclear security is applying border control with radiation portal monitors (RPMs). However, Indonesia is a large country with three time zones. Such border control, then, might ‘slightly’ increase the possibility of finding the missing sources. This is not to mention that at those times there were no RPMs installed in the country.

Searching with helicopter equipped with a highly sensitive detector might be an idea. It will surely need a considerable amount of investment, including competency in interpreting the result of this aerial search. This is not what has happen in Indonesia, but this technology should be seriously considered in the future.

As part of State responsibility, regaining regulatory control after any disaster will be optimized with available resources and national situation. Consideration should also be given to the fact that State priority is usually given to the search and rescue of the victims, sheltering, providing food and drinking water, health care and no less important for trauma relief activities.

4. REMARKS

For a State such as Indonesia, which lies in the ring of fire, prevention and preparedness should be a priority. It should be done through licensing process and guidance occasions to the licensee. Inspection and law enforcement can also be used to ensure regulatory control over the radioactive sources. Since security response in the aftermath of disaster is likely not to be the case, a national response scheme should be prepared. Sustainability, then, is the key issue to the success of national performance both in emergency preparedness and response, and in nuclear security.

Learning from this disaster response, BAPETEN accelerated its plan to adopt and adapt both the Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [9] and the Code of Conduct on the Safety and Security of Radioactive Sources [10] into new government regulations amending previous versions. As stipulated in Act No. 10/1997 on Nuclear Energy, BAPETEN has a task to promulgate acts or government regulations, and propose them to the president. The government regulation is signed by the president after consent of all related government bodies. According to the Act, the chairman of BAPETEN also has a mandate to enact a BAPETEN Chairman Regulation, as technical instruments to government regulation. This paper also described the development of regulations on radiation safety and security of radioactive materials following the Great Aceh Tsunami, in 2005. It can be concluded, then, that the Government of Indonesia has identified and learned how effectively to control radioactive materials considering any possible hazards, including earthquakes and tsunamis.

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LESSONS LEARNED FROM THE RADIOLOGICAL ACCIDENT IN MAYAPURI, NEW DELHI

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Abstract

In the past, there were several reported incidents and accidents throughout the world due to inadvertent radiation exposure causing serious radiation injuries to members of the public due to the presence of radioactive sources in the public domain and scrap yards. In April 2010, for the first time in India, a radiation accident occurred due to the dismantling of a gamma cell, housing ^{60}Co radioactive source pencils, by the workers in a scrap shop located in the Mayapuri area of New Delhi. This resulted in high radiation exposures to seven people, of whom one succumbed to radiation sickness. Officers from the Atomic Energy Regulatory Board (AERB) and personnel from national emergency response agencies were involved at various stages of source recovery operations. It was revealed that the accident due to a 'legacy' source originated from a university. Several actions have been initiated by the AERB to prevent such accidents in future and lessons learned by stakeholders.

1. INTRODUCTION

Radioactive sources find many applications in medicine, industry and research. One such application of radiation is the use of gamma cells (also commonly known as gamma chamber/blood irradiator), in which the sealed source is completely enclosed in a dry container constructed of solid materials and is shielded at all times, and where human access to the sealed source and the volume undergoing irradiation is not physically possible in the designed configuration. Such type of gamma irradiation facilities is categorized by the IAEA as Category 1. These are used for variety of purposes, basically for research and development work such as sterilization or microbiological reduction in medical and pharmaceutical supplies, studies on radiation processing of food stuffs, radiation effect studies, chemical and polymer synthesis, whereas a blood irradiator is primarily used for irradiation of blood and blood components. The gamma cells contain ^{60}Co or ^{137}Cs as radiation source. The source requirements for any particular irradiator may range from about 50 TBq to 500 TBq. One of the disused gamma cell housing about 0.69 TBq of ^{60}Co was involved in this accident.

2. DETAILS OF VARIOUS PHASES OF THE RADIATION ACCIDENT

The response action to handle this radiological accident included the phases in Table 1.

TABLE 1. RADIATION ACCIDENT PHASES

Phase of emergency	Action
Initial phase	Emergency first response
Accident control phase	Radiation protection
Post-emergency phase	Cleanup

2.1. Initial phase

In the afternoon of 7 April 2010, the Atomic Energy Regulatory Board (AERB) — the national radiation regulatory body — received a message from a reputed hospital located in New Delhi, stating that one person, aged 32 years and owner of a scrap shop in the Mayapuri industrial area, New Delhi, had been admitted on 4 April 2010. The message also stated that the patient had symptoms indicative of suspected exposure of radiation and requested advice on further course of action. The hospital was advised by experts for the proper medical management of the radiation victims based on the symptoms, biodosimetry and follow-up. Pursuant to the above, officers from the AERB visited the place immediately with radiation detection equipment and monitored the radiation levels at various locations (see Table 2) near the scrap shop in the evening of 7 April 2010. The scrap shop and a couple of nearby shops were found to have elevated radiation levels. The entire area was cordoned off by City Police Authorities for limiting the access to the high radiation level areas.

TABLE 2. RADIATION LEVELS OBSERVED IN THE SCRAP SHOPS

Location	Radiation level (mSv/h)
On the entrance of identified scrap shop	10–15
Inside a shop adjacent to identified scrap shop	0.25–0.45
Inside a shop located rear side of identified shop	20
Inside of another scrap shop located about 300 m from identified shop	15–45

2.2. Accident control phase

Personnel from the AERB and emergency response agencies (ERA) reached the emergency site in the night of 8 April 2010, with radiation monitoring equipment and a transport container. After reaching the site, the team at first had a detailed survey of the location and also identified the source involved in the accident as ^{60}Co.

After the above exercise, the door of the identified shop was opened. The exact locations of radioactive material were found out with the help of a teletector. Since the observed radiation levels were high, an emergency response planning was undertaken to optimize the radiation exposure to emergency handling personnel. It was also decided to apply the dose apportionment method to minimize individual doses. During this operation, four pencil sources, three gunny bags and one drum containing radioactive scrap were recovered from the identified shop and transferred into the transport container. The operation lasted throughout the night until the afternoon of 9 April 2010. The recovered radioactive material was transported to the nearest authorized waste disposal agency for safe storage and further investigation (see Figs 1 and 2).

After recovery of the radioactive sources from the identified shop, a radiation survey of the entire scrap market was carried out by ERA.

On 13 April 2010, the AERB received information about elevated radiation level at another shop located in the same scrap market of Mayapuri, New Delhi. The location was cordoned off and instructed to have no occupancy near the shop. In the same night, personnel from the AERB and ERA reached the site. The team carried out a radiation survey of the shops and observed a radiation level in the range of 10–100 μSv/h. The team executed the operation for recovery of the source(s) late at night because of no occupancy during the night time and ease of management. The team recovered one ^{60}Co source pencil and one

FIG. 1. Source search operation.

FIG. 2. Source transport container.

cylindrical source cage approximately 25 cm in diameter, with a source pencil still in intact condition in one of the slots. The recovered sources were transferred to a transport container and transported to the nearest authorized waste disposal site. The team carried out extended radiation survey of approximately 800 shops and no elevated radiation was observed during this survey (see Fig. 3).

FIG. 3. Personnel carrying out radiation survey in a scrap shop.

On 16 April 2010, the AERB received information that one of the scrap dealers was admitted to a hospital in New Delhi with localized radiation injury. A ^{60}Co slug was discovered in the person’s wallet. The radiation level measured on contact was in the order of 10 Sv/h. The approximate activity estimated as 20.27 GBq. Initially, the source was kept in a source storage container available in the hospital, and later it was transferred to a transport container and was transported to the nearest authorized waste disposal agency for safe storage and further investigation.

2.2.1. Investigation of the origin of the source

During 16–17 April 2010, the exact application of the source as well as its origin was not known. A visual inspection in a hot cell and inspection by autoradiography technique of the sources indicated that the source must have originated from a gamma chamber. It also revealed that the source cage has 48 slots and the dimensions of the source pencils are entirely different from the indigenous pencils. The marking on the source cage also showed that the sources were not manufactured in India. The activity estimation (about 0.67 TBq) showed that the sources must have been manufactured about 30 years ago. The visual inspection also revealed that there were cut marks on the recovered slugs.

After a long interaction with the victims of radiation exposure and showing photographs of gamma cells, one of the victims recognized the gamma cell and informed that such an object was cut by one of the scrap dealers in Mayapuri. The scrap dealer was identified, and on subsequent interrogation it was revealed that this gamma cell was procured by the scrap dealer through an auction from a university. An officer from the AERB immediately visited this university and confirmed the statement given by scrap dealer.

2.2.2. Description of the equipment involved in the accident

The equipment involved in the accident was a gamma cell (gamma cell model 220, manufactured by Atomic Energy of Canada Limited (AECL), see Fig. 4). The gamma cell was purchased by one of the university departments from AECL in 1969, when the regulatory framework was at an evolving stage in India.

FIG. 4. Model of the gamma cell model 220 (shown to the victims for identification).

The equipment has a cylindrical cage (see Figs 5–7) with 16 pencils (which has a capacity to hold a maximum of 48 numbers of pencils), shielded by approximately three tonnes of lead. Each pencil had seven ^{60}Co slugs and two dummy spacers. The total activity of the cell with 112 slugs (16 × 7) was 147.186 TBq as of August/September 1969. Activity content in the pencils was in the range of 6.15–10.21 GBq and the activity content in the slugs was in the range of 740–3219 GBq. In April 2010, the total activity content was estimated at 688.2 GBq. The activity content in the pencils is between 29.6–48.1 GBq and the activity content in the slugs between 3.39–20.20 GBq.

FIG. 5. Dismantled gamma cell at Mayapuri scrap shop (source cage and source).

FIG. 6. The name “ASTROIDSTER” was found engraved outside the source cage.

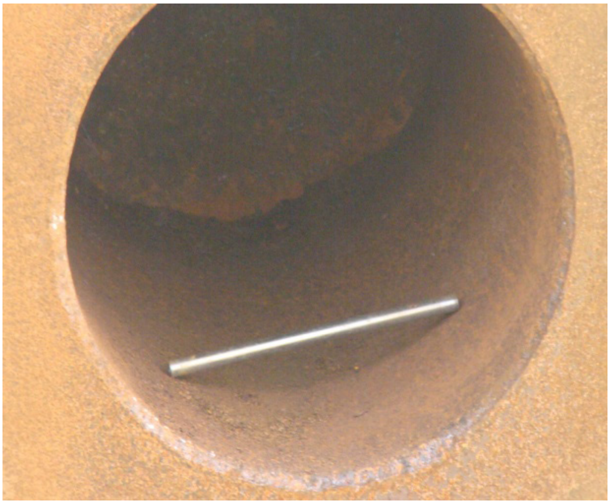

FIG. 7. Pencil recovered on 14 April 2010.

2.2.3. Accountability of radioactive sources

On subsequent investigation, it was found that the university had procured the gamma cell in 1969. It had not used it in 15 years and it was written off a metal scrap without obtaining prior permission from the national regulatory body. The AERB, through its database and information received from the AECL, confirmed the activity of ^{60}Co supplied. This in fact helped in ensuring the activity of sources that were recovered and the activity of the sources that remained after decay. Both activities were found to be approximately the same.

2.3. Post-emergency phase

Because of the cutting exercise of ^{60}Co slugs, there was a spread of radioactive contamination around the identified shop. The recovery of contaminated soil, depending upon level of radioactive contamination, was recovered in various phases on 15–16 May, 22–24 May and 14–18 June 2010. Even after these soil recovery actions, a still very low level of contamination was observed in the soil. It was therefore decided to concretize the road to immobilize the available trace amount of radioactive contamination. During 14–18 June 2010, concretization of road was undertaken by the concerned agency. After the concretization of the road (about 6 in thick concrete), the observed radiation levels could not be distinguished from the natural background radiation levels (see Fig. 8).

FIG. 8. Personnel carrying out decontamination activities.

In this entire operation, more than 400 kg of contaminated soil and 100 kg of scrap were recovered and safely disposed of at the nearest authorized disposal site.

On 6 May 2010, the AERB conducted an awareness programme on radiation safety (see Fig. 9). The objective of this programme was to make people aware of recognizing radiation sources/devices and dos and don'ts in such cases.

3. NOTIFYING THE IAEA

On 22 April 2010, a notification of the event was communicated to the IAEA and a provisional rating of Level 3 (incident) on the International Nuclear and Radiological Event Scale (INES) was assigned. On 17 July 2010, another notification of the event was sent to the IAEA and a final rating of Level 4 (accident) on the INES was reassigned.

4. MEDICAL MANAGEMENT OF VICTIMS

On 7 April 2010, the AERB received information from a private hospital in New Delhi about a patient (Person A, Table 3) who was admitted on 4 April 2010 with symptoms indicative of radiation exposure, such as a loss of hair, blackening of skin, nausea and vomiting. During 8–13 April 2010, six more patients

FIG. 9. *A glimpse of an awareness programme.*

(Persons B–G, Table 3) were admitted to various hospitals in New Delhi with radiation induced symptoms. Out of the seven patients admitted, two patients had radiation induced burns, one of whom succumbed to radiation sickness. Another six people were discharged from the hospitals on various dates, the last one being on 24 May 2010. The individual doses to the patients affected by high radiation exposure as estimated by an appropriate biodosimetry technique are given in Table 3.

Even after discharging the patients, a medical assessment on a daily basis of all the radiation victims was carried out. Later on, this frequency was gradually reduced to weekly, quarterly and then annually.

5. CONCLUSION AND LESSONS LEARNED

The main cause of this accident was the unauthorized disposal of radiation source violating statute for safe disposal of radiation sources by the university. The radiological accident at Mayapuri, New Delhi, has been an eye opener for users of radiation sources in India and particularly the academic institutions, the regulatory body, other concerned agencies and the general public. Nevertheless, the Mayapuri radiological accident has provided further confidence in handling such radiation emergencies efficiently.

TABLE 3. ESTIMATED DOSE EVALUATED BY BIODOSIMETRY TECHNIQUE OF AFFECTED PEOPLE

Name	Estimated dose due to single exposure (Gy)	Dose assuming protracted exposure of 1–2 days (Gy)
Person A	3.7	6.8
Person B	0.6	0.9
Person C	0.4	0.6
Person D	1.6	2.8
Person E	1.8	3.1[a]
Person F	1.2	3.0
Person G	1.3	2.3

[a] Person died due to radiation sickness.

The main lessons learned and actions are:

(a) Various regulatory actions are undertaken to find out the presence of legacy sources, if any. This involved, among other things:
- Communication with concerned universities in India which may be in possession of radiation sources;
- Issuance of circulars to various government agencies and institutions using radiation sources;
- Contacting suppliers (national/international) of radiation sources.

(b) Verification and updating inventory of radiation sources being used in India.
(c) All the known suppliers of radiation sources worldwide were contacted to provide details of the sources supplied by them over the years.
(d) Spread of awareness on regulatory requirements by way of issuing notices through print media.
(e) Training programmes on the safe use and secure management of radiation sources were conducted at various educational and research institutes.
(f) Repeated communications with users (including universities) were made to improve the compliance with the requirement of submission of periodic safety reports to national regulatory body.

(g) Regulatory inspections of radiation facilities have been significantly enhanced.
(h) An e-Governance project (eLORA, i.e. the e-licensing of radiation applications), a web based interactive system for managing the regulation of radiation sources and facilities is being implemented.

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MANAGING EMERGENCY PREPAREDNESS AND RESPONSE
Challenges and benefits of safety and security integration

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Abstract

It is now widely recognized within the international community that nuclear safety and nuclear security work towards achieving the same goal — that is, to protect people and the environment from the harmful effects of ionizing radiation. In practice, the applied methodologies to achieve the common goal of the two disciplines share similar elements which support evidence based, risk informed decision making processes. However, at times other operational planning and management elements of nuclear safety and nuclear security can vary significantly, and in many circumstances this is necessarily so. In an operational sense, this can lead to specific challenges of communication and cooperation, and is particularly evident during the management of emergency preparedness and response.

These challenges typically require deliberate and positive intervention by leaders within organizations, in order to ensure that an integrated approach is adopted and applied. The paper explores some of the nuances associated with safety, security and emergency preparedness and response, it also attempts to identify a common language which can increase the understanding between the two disciplines, and finally examines emergency preparedness and response as it applies to case studies, in order to identify positive approaches to safety and security integration.

1. BACKGROUND

National level emergency management planning has in recent years moved from a collection of individual hazard specific plans to comprehensive and integrated all known hazards plans (pp. 3–4 of Ref. [1]). This is attractive because many emergency management undertakings, both safety and security related, share complimentary capabilities in their preparation and during the conduct of a response. This has implications for organizations involved in emergency management as they need to implement a broad range of knowledge and capabilities from various disciplines to ensure that safety and security personnel complement each other to enhance the response and thus improve the resilience of communities. This paper describes contemporary emergency management frameworks and highlights the benefits of safety and security integration by exploring emergency preparedness and response case studies specific to the nuclear and radiological industry.

When we observe the cause of major accidents or incidents in the past, we are repeatedly met with the realization that they have occurred due to situations which were not previously identified or were considered to be incredible at the time. Being prepared for the unexpected or the unbelievable raises additional challenges for emergency planners, particularly when States are faced with limited time and resources. However, with integrated knowledge and experience from a range of safety and security disciplines, planners should be more prepared to prevent the failure of recognizing hazards, and be better placed to responds to future threats that are unforeseen.

In the past, and somewhat erroneously, the words hazard and risk have been used interchangeably to describe potential types of situations which result in the need for a response. It is important to understand that hazards typically consider sources of potential loss or damage to the public and environment and we immediately recognize that all hazards fall within the categories of natural or human induced hazards. The term risk, however, is generally used as an estimate of the product between the consequential impact and likelihood that a hazard imposes to a community or the environment. However, some risk assessment methodologies can be threat based, and others vulnerability based and we need to be mindful of the myriad different risk assessment approaches adopted by different groups or professionals.

We now know that the impacts which particular hazards can impose upon a community range across physical damage to infrastructure, economic impacts, adverse health effects or loss of life, psychological impacts and sociopolitical implications to name a few. What is important to recognize now for emergency management planning is that no longer should we solely consider the physical damage and immediate loss of life that occurs when an incident or situation develops; we now also recognize the societal impact of hazards which in some circumstances can create greater challenges which also require management (p. 10 of Ref. [1]).

2. THE EMERGENCY MANAGEMENT FRAMEWORK

Emergency management organizations in many contemporary societies adopt the comprehensive prevention, preparedness, response and recovery

(PPRR) framework in order to develop systems and measures to reduce the vulnerability and thereby to increase the resilience of communities to particular hazards (pp. 1–4 of Ref. [2]). For the nuclear and radiological industry, this is also the case. In order to illustrate the relationship between vulnerability and resilience, we can turn to the following simplistic example: consider a remote community living in a pine forest plantation without a fire brigade during the peak of summer. It is reasonable to expect that this community is likely to be highly vulnerable to bushfires. On the other hand, that same community with well developed fire resistant shelters, long term food, water and sanitation provisions, preplanned evacuation modes and routes, coupled with regular training and exercising, would be significantly more resilient to the threat of a bushfire. It is across this dynamic, yet linear, vulnerability versus resilience scale for which many PPRR frameworks are designed to operate with the intent of creating sustainable and resilient communities against recognized hazards.

With comprehensive all known hazards strategies being integrated into the PPRR framework, traditional safety and security disciplines are now encouraged to integrate their activities throughout all phases of the framework to ensure that the resilience objective is comprehensively maintained. Key to the challenge of integration is the communication and understanding of each discipline's methodologies and the common recognition for the mutually supportive contributions each can make during emergencies. This raises many challenges for senior management within organizations and for strategic, operational and tactical emergency management planners who are all likely to be involved in, or at least be responsible for, the effectiveness of the response, during or after radiological or nuclear emergencies should they occur.

Fortunately, among the difficult challenges described above, there remains a high level mission statement or shared commitment within the nuclear and radiological industry, which can be used to focus the collective efforts by safety and security professionals and that is to recognize that both disciplines share the same common purpose:

— To prevent the harmful effects of ionizing radiation to people and the environment.

The applicability of this mission statement is well understood by both security response and safety response organizations involved in a radiological or nuclear emergency. Moreover, both safety and security disciplines also share similar risk management strategies which support evidence based, risk informed decision making. That is to say, in order to make operational or tactical decisions, evidence needs to be collected or observed and risks need to be identified, characterized and analysed, prior to making decisions and initiating actions.

As an example, although somewhat controversial, many emergency response organizations would argue that atmospheric modelling tools are of limited use during the response to a nuclear or radiological emergency, and that emergency response organizations require field data to be collected, analysed and assessed in terms of radiological risk (operational intervention levels [3]) prior to public protective actions or decisions being implemented. However, others would argue that modelling tools represent an excellent planning guide for scaling and designing emergency preparedness and response requirements for nuclear and radiological facilities in the prevention space of the PPRR framework, which again, is analysed and assessed in terms of the radiological risks prior to response measures being implemented. This is the case for both safety and security planning considerations, safety in the sense of scaling the radiological hazard to an accident or incident, security in sense of assessing the vulnerability of a facilities protective security system to theft or sabotage. Irrespective of particular positions on the value placed upon modelling tools used prior to or during an emergency, the process of evidence based, risk informed decision making is still applied.

However, noting the similarities in approach to risk assessment described above for safety and security, the key challenge or difference in methodology between safety and security throughout all phases of the PPRR framework is recognizing that safety is usually maintained through collaborative, shared and transparent approaches. Where for security the traditional methodology is to apply principles which protect information and knowledge of vulnerabilities so as not to compromise the success of an operation or undertaking. In almost all security relevant circumstances, this is an appropriate approach to implement when dealing with incidents or situations which have the potential to occur either with or without malicious intent.

Unfortunately, whilst representing a comprehensive strategy to ensure community resilience for incidents and emergencies, applying the PPRR framework cannot be undertaken in a linear fashion for all incidents. Nor is it assumed to be applied in similar scales and magnitudes for all situations. Many circumstances could require preventative security response actions to be undertaken in parallel to post-incident safety response activities, an example includes recognizing situations where the response to safety incidents can be maliciously exploited such as intruders gaining access to a facility during a fire evacuation where reduced access control is introduced. It is for these types of situations which require a measured and deliberate approach by senior managers, planners and responders to ensure that a comprehensive, harmonized and integrated safety and security response is established for managing events.

The following section is dedicated to exploring a few case studies which demonstrate situations where safety and security response actions should be undertaken in parallel or concurrently. An additional aim is to also highlight the value in integrating safety and security response actions for these brief descriptions.

2.1. Case study 1: Response to the detection of illicit radiological or nuclear cargo

On the 'left of bang' scale of the PPRR spectrum, an example requiring safety and security integration includes the detection of a suspected illicit shipment or cargo container containing radiological or nuclear material at a seaport. This situation requires an integrated X ray explosives analysis and potentially law enforcement investigations to be initiated in parallel to conducting radiological characterizations and entry assessments of the container. In this situation, the requirement for integrating both safety and security activities is primarily to ensure that the container does not function or detonate due to explosives or other items not yet detected. The all hazards approach is adopted until malicious intent is ruled out or able to be managed at the scene, and it is understood that the container cannot be assumed to be safe for further analysis until the security threat is managed. Therefore, cooperation of safety and security experts needs to be undertaken in order to develop and plan an appropriate concept of operations for dealing with this type of situation.

2.2. Case study 2: Response to the detonation of a radiological dispersal device

On the 'right of bang' scale of the PPRR spectrum, an example requiring integration includes a post-radiological dispersal device detonation. This situation necessarily requires integrated site security, forensics and information exploitation activities to be coupled with the coordination of conventional safety activities such as treating injured or wounded persons, conducting evacuations and decontamination, without jeopardizing any forensics collection activities. The immediate requirement for security activities to be undertaken in parallel with safety activities is primarily due to an understanding of the potential for additional devices to function or detonate. This situation requires special planning and technical support organizations to assist with the response. This can include explosive ordinance detection and mitigation experts and specialist forensics and criminal investigators who are required to coordinate with conventional response organizations, which are usually augmented by radiological detection specialists. Naturally, complex command, control, communications and intelligence arrangements based upon the universal incident command system are required for the successful execution of this type of response operation (pp. 43–52 of Ref. [4]).

3. CONSIDERATIONS FOR INTEGRATION

So how do we ensure that emergency preparedness and response planning and ultimately the response actions are conducted in a comprehensive and integrated manner? Whilst it is not likely to be a surprise, the key to integration for many organizations is communication, joint planning, training and exercising.

The first and most difficult task is communication. Senior managers of all organizations involved within the nuclear industry and emergency management planners need to ensure that all disciplines collectively engage with a common mission statement, a common understanding of the PPRR framework and ultimately, a common language as the basis for all discussions. Educating safety and security response organizations of the language and nuances associated with each discipline is a difficult task. This is particularly difficult when legacy terms and old assumptions are introduced.

Have you ever simultaneously asked safety and security experts to explain the difference between the following questions?

— What is a safety event and what is a security event?
— What is an accident and what is an incident?
— What is a threat assessment?

Those close to the nuclear industry will tell you that the responses to these questions will vary widely from each discipline. There is an understanding that those traditionally involved in nuclear security will initially explain their responses from an understanding of the deliberate or accidental nature of the stimulus to an event. However, those traditionally involved in safety would answer these terms in the context of the scale or magnitude of an event. Looking at the threat question for example, the IAEA threat categorization requirements in IAEA Safety Standards Series No. GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency [5], recommends the use of threat categories I–V, which largely focus upon the consequential radiological impact and scale of potential events. On the other hand, when nuclear security experts conduct a threat assessment, States typically consider the combined product of the assessed intent versus the assessed capability of an adversary who may act deliberately with malicious intent (p. xi of Ref. [6]).

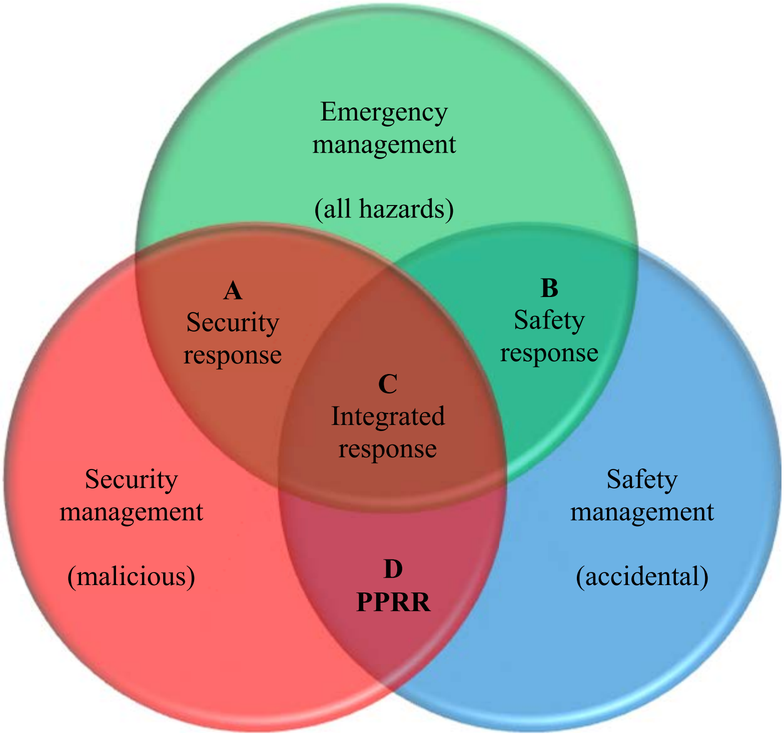
Ultimately, whilst it is optimal for organizations to establish a common language to be used in emergency management, it does not really matter what definitions are used by both disciplines. What matters is that there is a keen awareness of the similarities and an understanding of the differences and the reasons for them, and a respect for the mutual contributions each discipline makes to the common mission statement. To achieve this, senior managers are required to cultivate and nurture positive cultures of cooperation and understanding within the workplace, and one good method of achieving this is establishing deliberate and objective discussion workshops that are focused upon sharing and communicating each disciplines activities.

The practice of sharing and communicating activities extends to the PPRR framework. Emergency management teams within organizations are in a unique position in order to demonstrate leadership and achieve safety and security integration due to the cross-cutting nature of emergency response planning, training and exercising programmes.

An example of this cross-cutting nature is the shared knowledge of the role of security response, which is loosely described as the ability to prevent the onset of conditions which may allow an adverse situation to occur, this description is paramount for conventional response personnel to understand. Similarly, understanding the safety response methods in radiation protection should be a principle consideration for security response personnel, and similarly be embedded into their planning, training and exercise programmes. Although described in very simplistic and basic terminology, both scenarios demonstrate that there remains a mutually supportive benefit to each discipline when activities and knowledge are combined. In this manner, and when integrated, emergency responses to radiological and nuclear events will ultimately achieve a force multiplying effect, that is to say, that the success of a response will become greater than the sum of the individual parts.

The following Venn diagram (see Fig. 1) visualizes the cross-cutting relationships between emergency management, safety management and security management, and also highlights the unique position that emergency response staff maintain within organizations in order to demonstrate leadership by encouraging and fostering collaborative and integrated activities between safety and security professionals.

In Fig. 1, sector A demonstrates that as part of security management, a security response can be required in the preventative spectrum of the PPRR framework. We understand this from our knowledge of plans and arrangements for security response forces who prevent intruders gaining access to nuclear facilities. Sector B demonstrates that as part of safety management, a safety response is required in the response spectrum of the PPRR framework, and we have numerous nuclear accidents and events which demonstrate this requirement.



Note: PPRR — prevention, preparedness, response and recovery.

FIG. 1. The safety, security and emergency management cross-cutting relationships.

Not often well understood by all stakeholders, however, is sector C, the integrated response actions which are undertaken collectively. Examples of these scenarios are highlighted throughout the case studies contained within this paper.

However, the benefits of integration goes further than simply understanding fundamental descriptions of each disciplines tradecraft in the planning phase. Useful technical and operational information should also be shared between safety and security personnel during a response. The next two case studies are dedicated to demonstrating the value of combined information sharing activities between safety and security experts during an integrated response.

3.1. Case study 3: Stolen radioactive sources and subsequent search operations

During a security response situation dealing with missing or stolen sources, benefits to integration include safety experts sharing a broad range of information with security experts responding to the incident. This may include design and construction information of sources and their containers, data of regulated entities storing particular sources, labels and serial number information of sources, or even sharing the strengths and limitations of particular radiological detection equipment and technologies used in a search operation. This largely safety related information is critical to the success of a security operation in locating missing or stolen sources, and in some circumstances may also assist law enforcement personnel in determining the identification and location of adversaries, and ultimately provide sufficient evidence for their eventual prosecution.

From a safety perspective, security experts may also be able to assist safety investigations of accidents or incidents. Understanding the vulnerabilities of protection systems, knowing where to exploit information sources and interview witnesses or personnel, establishing timelines, confirming facts and analysing broad forms of human, media and electronic data are all skills that typify traditional security experts in many industries who can add additional perspectives and different views. These specialist skills and techniques which are usually not found within radiological and nuclear safety organizations are relevant to be incorporated during the investigation of accidents and an example includes the following situation.

3.2. Case study 4: Accident investigation and dose reconstruction of a poorly packaged source.

Consider a transportation incident where a poorly packaged source has been discovered dislodged from its package on an aircraft in a foreign country, which originated or transited in your own country. Again, an all hazards approach may be adopted in order to initially rule out that the incident did not occur maliciously. Assuming that it has already been established that the incident did not occur maliciously, one of the safety goals might be to determine the potential doses to the people onboard and to those working around the cargo area of the aircraft through conducting a dose reconstruction exercise.

To successfully achieve this with any level of confidence, safety experts need to make a number of assumptions in their calculations of the proposed doses to individuals. Security experts can greatly assist in determining the pattern of life for the source from a security perspective, including which personnel may have been exposed during transit, and the likely occupancy times of people in the proximity of the source. Security experts with investigative skills, particularly those who understand and can investigate the security arrangements in transit and transportation routes, changes of aircraft and cargo at transit ports, interview employees and officials working in and around the cargo from a security perspective, are essential for an accurate dose reconstruction to be determined and to establish any lessons learned.

It is clear from the case studies presented that in the context of the PPRR framework, there are many benefits to integration of safety and security, particularly with emergency response. The examples contained within this paper are not exhaustive or complete by any means, yet they attempt to highlight some of the operational subtleties which are common to many other emergencies. With this in mind, we now turn our attention to organizations and what they can do in order to take advantage of the benefits that have been considered.

4. TIME FOR CHANGE: THINK SMARTER, NOT HARDER

In today's challenging economic environment, it is always a high priority for organizations to identify ways in which to minimize the duplication of effort and to harness the collective best of individuals or groups through developing new norms of behavior by establishing shared responsibility and integrated activities.

Modern safety practices are moving to a holistic (or systemic) approach to safety and security that addresses the key characteristics of technology, human factors and organizational factors and importantly how each interacts with the others to contribute to safety. The interaction of safety and security in this regard is important to achieving good safety performance and security performance (pp. 76–77 of Ref. [7]).

Key to achieving these priorities particularly when integrating safety and security activities is the role of leadership within organizations to foster and nurture collaborative and cooperative behaviors. When observing the PPRR framework, we immediately recognize that both disciplines have roles to play in each element of the spectrum. Safety and security work towards establishing a range of infrastructure, systems and measures to prevent the onset of accidents or incidents occurring. Both disciplines prepare plans and arrangements for events which may occur in the future, respond to events should they eventuate and ultimately, they both also ensure that organizations, society and the environment can recover from the impacts of abnormal events as quickly as possible and commence the resumption of normal life.

Recognizing these commonalities should form the basis for a number of actions by senior managers and planners in order to implement the following suggestions to introduce safety and security integration into organizations:

- Establish and recognize the equal value and contribution that both safety and security disciplines contribute to the common mission statement;
- Implement opportunities to share and communicate experiences, roles and responsibilities for safety and security response groups and individuals;
- Develop and promote common languages and a common understanding to form the basis of planning, training and exercising activities;
- Conduct joint planning, training and exercising at the strategic, operational and tactical levels of responding organizations with the objective of exploring ways to overcome challenging subtleties and nuances inherent to each discipline.

5. SUMMARY

The suggested activities above aim to assist organizations to break down the professional barriers between safety and security by focusing their efforts towards a common goal: by improving emergency preparedness and response, a universally recognized critical component of the radiological and nuclear industry.

Whilst is it understood that there are circumstances which require purely security response or purely safety response actions, there are recognizable circumstances where response efforts would be significantly enhanced when integrated.

Emergency management's unique position as a cross-cutting discipline maintains an opportunity and a responsibility to assist this process by ensuring that communication, coordination and harmonization activities are conducted with a respectful understanding of each disciplines historical foundations. This in the future should translate into substantially increased performance by all responding organizations when dealing with radiological or nuclear emergencies.

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ENHANCING RADIOLOGICAL EMERGENCY PREPAREDNESS AND RESPONSE IN SOUTH EAST ASIA THROUGH APPLIED TRAINING AND CAPABILITY DEVELOPMENT

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Abstract

The potential malicious use of high activity radioactive sources remains a security concern for governments and the international community. The Code of Conduct on the Safety and Security of Radioactive Sources recognizes the importance of having in place the expertise, measures and tools to detect, respond to and mitigate the consequences of accidents or malicious acts involving radioactive sources. The Australian Regional Security of Radioactive Sources Project has collaborated with States in South East Asia to enhance their radiological emergency preparedness and response (EPR) capacity to security related incidents involving radioactive sources out of regulatory control. The aim of this collaboration is to improve and maintain the national core technical capabilities to enable an effective and safe response to any security related radiological incident. The main elements of this collaborative approach are: (a) identifying the priority areas for training through needs analysis; (b) strengthening individual professional expertise through a structured approach to training; and (c) enhancing individual agency and national nuclear and radiological EPR arrangements and capabilities. This collaboration has enhanced the sustainable development and implementation of South East Asian States' national EPR capabilities and arrangements to ensure detection, response and mitigation measures are effective, systematic and well integrated within their national framework.

1. INTRODUCTION

The importance of having an effective response to mitigate the consequences of malicious acts involving radioactive materials, such as a ‘dirty bomb’, has been recognized by governments. Their ability to respond successfully to such events is increasingly seen as an essential part of national security [1]. The international community is recognizing the importance of implementing international cooperation and assistance programs in this regard. Additionally, the Code of Conduct on the Safety and Security of Radioactive Sources [2], in provisions such as paras 5(a)(iii), 8(g) and 9(b), recognizes the importance of having in place the expertise, measures and tools to detect, respond to and mitigate the consequences of accidents or malicious acts.

The Australian Nuclear Science and Technology Organisation’s (ANSTO) Regional Security of Radioactive Sources Project has collaborated with several South East Asian States to enhance their radioactive source security arrangements and their radiological emergency preparedness and response (EPR) capacity to respond effectively to security related events and situations involving radioactive sources out of regulatory control [3–5]. The aim of the collaboration is to enable an effective and safe response to security related incidents involving radioactive sources at any location by providing training to improve and maintain essential national technical response capabilities. This includes equipment and expertise, and the organizational and procedural arrangements to support them. Participants are from the national nuclear regulators and operators and in some circumstances the military, emergency services and other government agencies that have roles and responsibilities for responding to a nuclear or radiological emergency. The collaborative activities include tailored workshops, training courses, field exercises and train the trainer activities, each designed to enhance the responding agencies’ capacity to sustainably deliver their own EPR programme of training and exercises. The competence, experience and ability of individuals and teams to perform radiation monitoring, source search and recovery, dose reconstruction and radiological assessment, and advice are further developed and enhanced. Organizational capacity is increased through the development of written emergency plans, procedures, guidance and by the provision of equipment. A key feature of the collaboration is that it is driven by a self-determined needs analysis and identification of the States’ current radiological EPR status and priorities. Consequently, this has led to different, equally effective, approaches within individual countries. For example, the Philippines has developed a procedure manual for its radiological emergency response teams, which is tested through a regular exercise programme and is further developed as result of lessons learned from these exercises. Indonesia has developed roles and responsibilities for individuals and tests them through an emergency exercise programme involving continual review and improvement of the training material.

This paper describes the methods, activities and outcomes of Australia's EPR collaboration with agencies in Indonesia and the Philippines, and reviews the design of training material content, sustainability measures and the use of competencies' requirements.

2. EMERGENCY PREPAREDNESS AND RESPONSE TRAINING METHODOLOGY

The training aims to develop the capacity for nuclear and radiological EPR within a collaborating State or organization that is designed to be sustained by the State or organization. The methods of a systematic approach to training [6] are applied, including:

(a) Training needs analysis and assessment:
- — Information gathering, such as the current status, plans, procedures, equipment and capabilities, among other things, in regards to all nuclear and radiological EPR matters of the State and its relevant organizations;
- — Establishment of agreed EPR development priorities, requirements and goals.

(b) Development of action plans and agendas to meet identified and agreed training priorities and goals:
- — Identify timetable, expectations, constraints, key learning areas, outcomes or performance indicators.

(c) Syllabus development:
- — Each activity such as a workshop or exercise may have a different priority, focus or audience with the syllabus development recognizing and integrating these aspects;
- — Objectives, key learning areas, learning outcomes and expectations are defined and agreed.

(d) Deliver training activity and interim monitoring:
- — Assess its progress against the action plan, timetable and assigned outcomes for each activity;
- — Obtain participant feedback, conduct peer review and evaluation after each activity.

(e) Training programme evaluation, effectiveness, sustainability, assessment of achievements and lessons learned:
- — Was the overall goal achieved?
- — How are the participants going to continue and build on what they have learned?
- — How successful is the transfer of knowledge, skills and attitudes?
- — Document lessons learned and how can they be incorporated into future training.

As indicated in Fig. 1, the structured approach to training provides a step by step, iterative process for the development and continuous improvement of training programmes as a whole as well as the constituent parts such as the needs analysis, syllabus, learning outcomes and content development. As each development step is conducted, outputs can be reviewed against the identified needs and the agreed key learning areas. This allows feedback and improvement to be incorporated in the training material at each step of the development stage. This evaluation continues following training delivery, allowing the experience gained to further improve the content of such training to meet the needs of participants, including often changing or newly recognized needs. Embedded in this process is the means for participants to identify their own needs and constraints at an individual professional level based on their intended roles and associated responsibilities in an emergency and to recognize how this relates to organizational or national EPR goals and arrangements.

The key learning areas that generally apply to enhance the knowledge, skills and experience of participants include:

- — Goals, roles and responsibilities for EPR;
- — Scope of a response structure needed for a security related incident involving nuclear or radiological materials;
- — Effective use of radiation detection equipment in such incidents;
- — Relevant international guidance, decision making criteria and procedures;
- — Development and use of EPR plans and procedures;
- — Training and exercise design and techniques.

Each of these areas can be covered by a complementary mix of lectures, tutorials, discussion sessions, group work, and classroom, field and table top exercises. A list of potential topics that are covered in an EPR syllabus is in Table 1. Additional topics are included if identified through needs analysis.

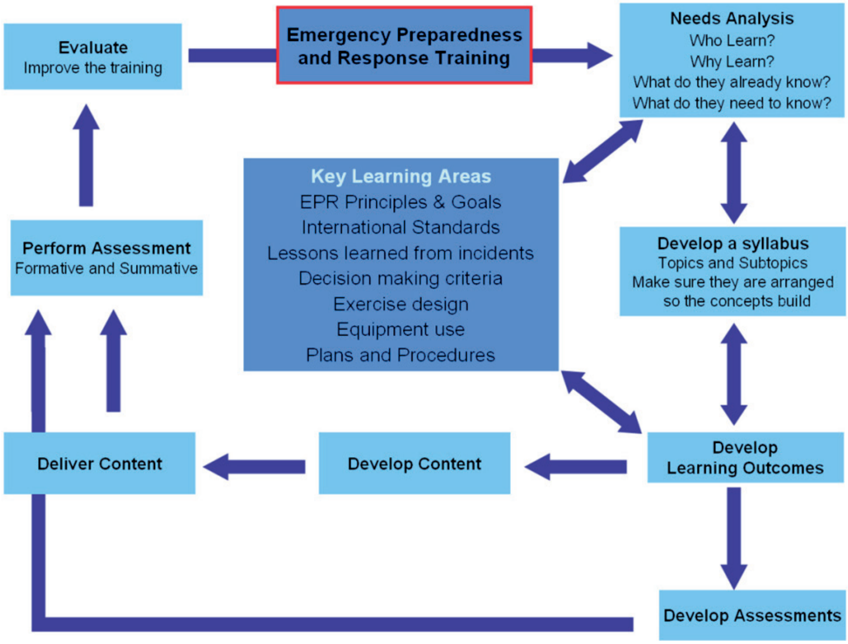

FIG. 1. Systematic approach to training development loop.

TABLE 1. EMERGENCY PREPAREDNESS AND RESPONSE TOPICS

Fundamentals
(a) Goals of emergency response (GS-R-2)
(b) Expected phases of a response (including relevance to on- and off-site operations)
(c) Lessons learned in radiological incidents
(d) Overview of the IAEA First Responder manual
(e) Overview of roles of first responders
(f) Role of incident commander (what the radiological assessor can expect)
(g) Role of radiological assessor (on- and off-site)
(h) Command control communicate
(i) First responder decontamination monitoring of people and equipment
(j) Emergency medical and field triage of casualties
(k) Radiation monitoring and air sampling instrumentation
(l) Basic plume modelling and calculations
(m) ERAIMS: Plume modelling software and the ANSTO experience
(n) Exercise planning
(o) RANET: A benchmark

TABLE 1. EMERGENCY PREPAREDNESS AND RESPONSE TOPICS (cont.)

Criteria and procedures
(a) Generic, operational intervention and emergency action levels (GSG-2) (b) Monitoring team deployment principles (airborne I-131 as an example) (c) EPR plans (d) Introduction to dose assessment (Section E of IAEA-TECDOC-1162 as an assessment resource) (e) Managing radiological response: Procedure D0 from IAEA-TECDOC-1162 (f) Source recovery/removal: Procedure D1 from IAEA-TECDOC-1162 (g) Decontamination of people and equipment: Procedure D2 from IAEA-TECDOC-1162 (h) Removal of radioactive wastes: Procedure D3 from IAEA-TECDOC-1162 (i) Tutorials and classroom exercises for each of the above criteria and procedures sessions
Train the trainer
(a) Learning outcomes (b) Structure and assessment (c) How to conduct a training needs analysis (d) Exercise planning: Review of target audience and competencies (e) Competency review and propose outline of classroom and exercise training (Who? What? How? Why?) (f) Devise an exercise (practical or table top) for a future workshop (g) How to evaluate an exercise
Exercises
(a) Radiological exposure device (RED) search and recovery practical exercise (b) Airborne radioiodine release from reactor sabotage practical exercise (c) Radiological dispersal device (RDD or ‘dirty bomb’) incident practical exercise (d) Interoperability between radiological assessors and response agencies table top exercise (e) Debrief and a review of learning outcomes following each exercise

International guidance and requirements, such as IAEA Safety Standards Series No. GS-R-2, Preparedness and Response for a Nuclear or Radiological Emergency [7], and IAEA Safety Standards Series No. GSG-2, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency [8], form the foundation of the training material. This includes lectures developed by ANSTO, for example, on our EPR experience and on radiation detection equipment and its effective use in response to a malicious act involving nuclear or radioactive material, as well as lectures adapted from other IAEA guidance material [7–14]. These provide the participants with a comprehensive overview of important EPR concepts with their application being reinforced through specifically developed classroom and field exercises.

Another important design component is that all training is compatible with the arrangements for the IAEA's Response Assistance Network (RANET) [9]. Whilst the immediate goal of the collaborative training is to enhance national EPR capabilities, this enables some States to consider working towards establishing accredited RANET field assistance teams. While RANET is not competency based it does establish minimum expectations or requirements for a State planning and preparing to build response capabilities. It therefore provides guidance on each of the functions, expertise, resources and products that would be required to respond effectively to a range of accidents or malicious acts involving nuclear or radioactive material anywhere.

Specific roles required for an effective response to a security related incident involving radioactive material covered by the training include:

- Decision makers, incident commander;
- Radiological assessor advising the decision makers, incident commander;
- Radiological field assistance team members who support the radiological assessor with data from the field;
- First responders such as police, fire brigade and ambulance, among others;
- Other supporting roles such as public/media information, medical and resource coordination, among others.

For the roles of the radiological assessor and the radiological field assistance team a set of competencies needed for each stage of an emergency response to a malicious act involving nuclear or radiological material has been developed as in Table 2. Each competency is a set of skills, knowledge and attitudes or behaviours required for an effective response by a person in that particular role.

TABLE 2. COMPETENCIES

Competencies	RA	FAT
Explain and demonstrate use of organizational standard operating procedures relating to support for a malicious act involving nuclear or radiological material	E	E
Identify and assess the information required to determine the support the field assistance team organization can provide	E	E

TABLE 2. COMPETENCIES (cont.)

Competencies	RA	FAT
Determine and restate the field assistance team's role in support to external agencies	E	E
Identify and assess the potential hazards from uncontrolled nuclear or radiological material	E	E
Identify and assess equipment and PPE for use by the field assistance team	E	E
Identify and describe protective actions from nuclear or radiological hazards for responders and members of the public (national or IAEA guidance)	E	D
Apply internal communications so they are accurate, timely and understandable	E	E
Interpret and synthesize information and communicate advice to the incident commander or designee, in simple understandable terms	E	D
Recognize and review the safety of field assistance team members from non-radiological hazards to ensure it is covered by the on scene arrangements with other responders (e.g. fire and explosives)	E	D
Demonstrate use of radiation monitoring equipment to measure dose rates and surface contamination	E	E
Determine and implement radiation monitoring to support the response	E	D
Set up inner cordoned area to meet national/IAEA criteria	E	E
Apply radiological protection procedures for all people and equipment entering and leaving the inner cordoned area	E	E
Identify and assess hazards based on measurements from uncontrolled nuclear or radiological material	E	D
Plan, practise and initiate safe recovery of identified nuclear or radiological material	E	E
Identify and initiate storage and transport requirements for nuclear or radiological material and waste	E	D
Compose reports as soon as possible after termination of deployment	E	—

Note: Summary list of essential (E) and desirable (D) competencies for the radiological assessors (RA) and other radiological field assistance team (FAT) members.

A recognized strength of the training is the strong practical focus giving many opportunities for the participants to apply what they have learned during ‘live agent’ field exercises. Practical exercises are designed to test these competencies using small, low radioactivity sealed sources and short lived radioactive contamination, for the scenarios of:

(a) Radiological exposure device (RED) search and recovery;
(b) Airborne radioiodine release from reactor sabotage;
(c) Radiological dispersal device (RDD or ‘dirty bomb’) incident.

These exercises allow radiological field assistance teams to practice radiation measurement, assessment and decision making skills and have clearly defined learning outcomes that describe what the participants should know or be able to do to successfully complete the exercise, thus demonstrating the associated competencies.

The RED search and recovery exercise provides training in some of the competencies important in dealing with uncontrolled radioactive sources, including those placed in public places with the intent to expose people to radiation. The focus is on search techniques and the use of radiation detection equipment for locating and recovering radioactive sources. Participants are required to develop an effective plan for dealing with an RED incident by considering site features, equipment, survey design, people and tasks, and present it to the exercise controllers. With the aim to safely locate any radioactive sources, measure dose rates, to identify found sources and advise the incident commander (played by an exercise controller) of actions required to make the area safe from the radiological hazard. Following advice, if requested by the incident commander, participants safely recover any radioactive sources found. The measured dose rates are used to set dose constraints and maximum exposure times. Source recovery should be practised to ensure any expected exposures for recovery personnel are minimized and kept within constraints.

The exercise on airborne radioiodine release from reactor sabotage is designed for participants to develop the competencies to monitor and assess simulated ^{131}I airborne radioactivity (as a marker radionuclide) and to recommend protective actions. Radiological assessors in the radiological field assistance teams are required to effectively deploy monitoring teams to conduct measurements of simulated airborne ^{131}I concentrations and to recommend protective actions based on the simulated monitoring results. Other radiological field assistance team members gain an understanding of the monitoring team deployment procedures and practise the use of monitoring equipment and reporting results. Every participant has the opportunity to carry out each of these roles and to practise accurate data transfer by radio communications.

The RDD incident exercise builds on the skills acquired by radiological field assistance teams through conducting the RED and airborne release exercises. This exercise is designed for participants to develop the competencies to provide effective radiological advice and support to other responding agencies in dealing with uncontrolled radioactive material in a contaminated environment. The aim is for participants to assess the incident notification information and to then determine the radiological field assistance team organization's role and provision of support, provide initial radiological safety advice for the incident commander to protect responders and public at or leaving the scene, and make a plan to respond to the incident including transport, equipment and personnel considerations. At the incident scene participants are required to erect an inner cordoned area or 'hot zone' barrier, locate and identify any radioactive sources, assess the radiological hazard, recover any items requested by the police and advise the incident commander on the precautions that all responders should take when working in the area. As part of the extended response phase, participants make the area safe from the immediate radiological hazard and when requested by the incident commander, safely recover any radioactive sources found. The radiological field assistance teams' on scene response is completed by briefing the incident commander on any further actions required (e.g. transport and storage) and writing a debrief report describing advice given, actions taken and their justification.

A further method to identify national EPR needs and develop competencies is a table top exercise on the interoperability between radiological field assistance teams and other emergency response agencies. This is a discussion exercise which identifies and reviews the roles, responsibilities and actions that organizations take in managing a radiological terrorist incident. The exercise provides participants with an opportunity to consider the application of international guidance in a national context and to better understand the roles, responsibilities, interfaces and procedures of other responding agencies. Participants review initial information regarding an incident and identify the nature of the radiological hazard; use national or IAEA guidance to recommend appropriate actions to protect emergency responders and the public; demonstrate an understanding of the priority for life saving actions and any precautionary medical follow-up; and consider the impact on the routine operations of emergency responders by the presence of radioactive contamination or materials.

The practical and table top exercises reinforce the EPR principles and goals, highlighting key components required for a successful emergency response. These exercises allow the participants to apply their knowledge and skills in an effective manner to the task of developing a competent radiological field assistance team capability.

3. COLLABORATIVE ACTIVITIES

Through regular application of the systematic approach to training methods described above, collaborating agencies are developing and implementing their own capacity building and training, and exercise design, conduct and evaluation for nuclear and radiological EPR focused on security related scenarios. The following provides recent examples of these collaborative activities.

3.1. Indonesia

Recent collaboration with the Indonesian National Nuclear Energy Agency (BATAN, Badan Tenaga Nuklir Nasional) includes a workshop in Serpong, Indonesia, in April 2011 to assess their needs and to understand the technical and organizational requirements necessary for a successful emergency response to a security related incident in Indonesia. Workshop participants discussed and reviewed BATAN's current technical basis, experience and capacity to prepare for, and respond to, radiological terrorism, following international best practice. They also analysed the need and opportunities for enhancement of those EPR technical and organizational capabilities; determined the priority topics and methods to address these; and developed a collaborative work plan.

Implementation of the work plan commenced with a workshop for BATAN radiological assessors in July 2011 at ANSTO, in Sydney, Australia, for senior BATAN staff. The workshop enhanced BATAN radiological assessors' expertise and capability, and provided suggested methods for preparing and presenting training programmes and exercises aimed at BATAN radiological field assistance team members and other emergency response agency personnel.

BATAN recognized the systematic approach to training as an essential tool in assessing training needs and producing EPR training materials. BATAN identified priority radiological EPR areas for further development in terms of the Indonesian national situation and their organizational structure and operations, including the need:

(a) To integrate the BATAN technical response arrangements with other Indonesian response agencies via the development and review of technical and procedural arrangements, training and exercises;
(b) To develop and maintain the knowledge, skills and equipment required for effective emergency response during security related radiological incidents through a systematic competency based training programme;
(c) To regularly implement training and preparedness exercises covering the range of security related radiological scenarios for first responders and other responsible agencies;

(d) To develop plans and standard operating procedures to support the roles, responsibilities, coordination and interactions of all agencies involved in security related radiological incidents, recognizing BATAN's specialist technical competency base.

To facilitate some of these identified needs a workshop for BATAN radiological field assistance teams was subsequently developed and conducted with BATAN staff. This workshop was held in November 2011, in Yogyakarta, Indonesia, for health physicists and radiological assessors from each of the four BATAN operated sites at Bandung, Pasar Jum'at, Serpong and Yogyakarta. Prior to the workshop, a structured needs analysis was conducted to identify which radiation detection equipment was required to complement and supplement BATAN's existing nuclear and radiological emergency response equipment capability. Equipment identified as a priority was donated by ANSTO and delivered for use by BATAN's radiological field assistance teams. As the workshop progressed, it was evident that the practical exercises improved participants' skills when using radiation monitoring equipment, employing search techniques and coordinating team activities to achieve an effective response.

Participants demonstrated good commitment and cooperation as part of a team to effectively apply the roles, responsibilities and expertise for radiological field assistance teams and radiological assessors, consistent with identified competencies. BATAN recognized the need for ongoing internal site drills and activities to maintain their readiness and skills. They also demonstrated a more complete understanding of the roles and responsibilities of other agencies responding to an incident not located at a BATAN site.

A subsequent workshop focusing on procedure and exercise development was held in April 2012 in Sydney for six senior BATAN staff members, four of whom had attended the previous radiological assessors workshop in Sydney in July 2011. It was designed to engage the senior BATAN participants to extend their expertise and competencies and to set the direction for further procedure and exercise development. This was achieved through the use of a structured, systematic and complementary mix of lectures and directed discussions that developed a roles and responsibilities framework, a list of procedures for further development, and consideration of how best to draft procedures and to develop exercises to test them.

Participants enhanced their understanding of the BATAN role and interactions with their National Nuclear Emergency Response Organisation and the National Terrorist Emergency Response Agency within the national framework. They demonstrated an improved understanding of the roles and responsibilities of other agencies responding to a radiological incident that is not on a BATAN site. The need to involve these agencies in joint exercises was recognized, as well as the need to develop radiation awareness training for incident commanders and on scene controllers. Cooperative preparation will allow better integration of BATAN's technical radiological response with the response actions of other agencies, and ensure an effective national response to malicious acts involving nuclear or radiological materials.

A good understanding of the internal roles, responsibilities and required competencies was obtained, along with a further training needs analysis facilitated by ANSTO and conducted by BATAN. In order to provide on scene support to a malicious act involving radioactive material anywhere in Indonesia the following target groups within BATAN requiring further training were identified:

— National radiological emergency manager(s) and radiological assessor coordinator(s);
— National BATAN field assistance teams, comprising: field team leaders; radiological assessors and radiation protection team members.

BATAN identified the aim of training these target groups is to build competent national BATAN field assistance teams for the provision of effective radiological support and advice during an emergency response to malicious acts involving radiological materials anywhere in Indonesia. The radiological support will include coordination and communication internally within the BATAN teams and with external agencies. A list of the minimum competencies required for BATAN staff to join the field assistance teams was drafted by the participants. Utilizing the training needs analysis method, the BATAN participants identified actions required by the target groups to provide on scene support to a malicious act involving radioactive material anywhere in Indonesia. From these actions a draft list of further competencies required to effectively perform them was developed; along with a list of potential procedures and guidance documents for use by the BATAN field assistance teams. These include the following topic areas:

(a) Roles and responsibilities;
(b) On notification;
(c) Preparation for deployment;
(d) Arrival at scene;
(e) Assess radiological hazard and carry out initial safety precautions;
(f) Make assessments and provide advice;
(g) Reducing the hazard;
(h) Termination of deployment;
(i) On return to BATAN.

Lastly, a training course for BATAN radiological assessors was held in September 2012 in Serpong. The training course was organized and funded by the BATAN Education and Training Centre (ETC), with the BATAN faculty responsible for developing and delivering the training material and ANSTO experts providing peer review. The faculty consisted of ten senior BATAN staff members. These are the expert faculty within BATAN for the ongoing development of EPR training for malicious acts involving nuclear or radiological materials: nine of whom had previously attended the radiological assessor workshop in Sydney in July 2011, and the procedures and exercise development workshop in Sydney in April 2012.

The training course syllabus designed by BATAN was a complementary mix of lectures, exercises, discussions and written tests. These included a range of essential radiological assessor EPR topics developed and adapted from IAEA guidance material and three exercises: RDD table top exercise; airborne radioiodine release from reactor sabotage field exercise; and RDD field exercise. The BATAN faculty presented all of the lectures and controlled each exercise. The training course was designed to allow participants to put into practice all the information from the lectures and discussions during the three exercises. The table top exercise was initially developed by the BATAN experts during the procedures and exercise development workshop in Sydney in April 2012. The airborne release and RDD field exercises were adapted by the BATAN experts from the previously provided ANSTO material to represent the local situation at Serpong. Its success was determined using education evaluation methods as part of the existing BATAN ETC quality management system. Furthermore, it has been integrated into their regular training curriculum.

The collaboration has led to BATAN taking effective ownership for the development and implementation of training for EPR to malicious acts involving nuclear or radiological materials based on identified roles and responsibilities. BATAN continue to recognize that integration of their technical response arrangements with other Indonesian response agencies is critical for the national response plan, and the best way to do this is to design and conduct joint exercises to test the effectiveness of emergency agencies and their procedures for responding to security related radiological incidents.

3.2. Philippines

Following EPR workshops conducted in 2008 and 2009 with the Philippines Nuclear Research Institute (PNRI), they developed a procedure manual for their radiological field assistance teams which was peer reviewed by ANSTO experts. It is based on IAEA guidance consistent with the development of competencies and operational requirements to support national response teams. Using this procedure manual a train the trainer workshop on EPR was conducted at ANSTO in August 2010 for senior staff from the PNRI. The success of this train the trainer workshop and the sustainability of the training provided are shown by PNRI developing and hosting their own EPR workshop for their Radiological Emergency Monitoring and Control (REMCON) Teams in Bataan, Philippines, in January 2011, where ANSTO experts provided peer review and further technical tuition. The workshop was successfully conducted by the PNRI faculty with useful lessons learned and future additions proposed for the PNRI procedure manual for REMCON.

As a result of the areas identified for improvement during this workshop PNRI developed an ongoing schedule of training activities for their on call response teams including:

(a) Equipment familiarization training for all REMCON members and new trainees;
(b) Drills and exercises using live sources and contamination to practise using personal protection equipment and instrumentation to bring the exercise scenarios under control.

ANSTO continues to support and peer review the REMCON team training and exercises conducted by PNRI, most recently in Baguio City, Philippines, in February 2012, at which the PNRI faculty effectively designed and conducted three EPR exercises. An ANSTO expert lectured on the Australian radiological emergency experience; participated as the incident commander in a series of exercises; and provided advice on and evaluation of the exercises, participants' actions and end of deployment exercise reports. The faculty consisted of six senior PNRI staff members and they are the expert faculty within PNRI for the ongoing development of EPR training. They all attended the Sydney workshop in August 2010.

The purpose of this Baguio workshop was to develop the competence and team work of the five REMCON duty teams in responding to security related radiological incidents in accordance with the guidance from the revised REMCON manual. This was achieved through a mix of lectures, group work, discussions, and source search and secure exercises. This gave the participants the chance to put into practice the knowledge and skills gained at previous workshops, drills and training activities. It also included an internal peer review and evaluation which enabled each REMCON team to observe the performance of the other teams. The workshop also exercised the teams in end of deployment report writing which is an essential skill in debriefing activities following the response to an incident.

4. CONCLUSIONS

The collaboration on security related nuclear and radiological EPR training and capability development in South East Asia has:

(a) Enhanced the relevant regional, national and local agencies' relationships;
(b) Improved expertise on radiation detection equipment for a range of potential emergency situations;
(c) Provided for better identification, development and implementation of emergency response roles, responsibilities and procedures including appropriate decision making criteria;
(d) Improved integration of the radiological response into an all hazards approach and related interagency interoperability.

Further, through the application of systematic approach to training methods, the collaboration has:

(a) Increased the local maintenance, development and self-sustainability of resources and expertise;
(b) Enabled national needs identification and development of appropriate local training courses and exercises, and development of related materials and techniques to address those needs;
(c) Improved testing of the effectiveness of EPR manuals and procedures;
(d) Enabled systematic assessment and review, with lessons learned incorporated to ensure continuous improvement of agencies' EPR capabilities.

Viewed from individual, organizational and national perspectives, the collaboration contributes to the capability and willingness to support responses to any nuclear or radiological incident, either safety or security related, within South East Asia. Such shared capabilities and willingness engenders mutual confidence, trust and understanding within the region on nuclear programmes generally.

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MANAGEMENT OF EMERGENCIES, SAFETY AND SECURITY EVENTS

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Abstract

The paper presents the organization to manage an event involving radioactive material outside nuclear facilities in the United Arab Emirates. The legislative framework for emergency preparedness and response to radiological event was only consolidated during the last few years. In a first step, based on this framework, a national organization to manage events involving radioactive material from the non-nuclear sector was established. Moreover, an event in 2011 in the United Arab Emirates regarding a radioactive source challenged the emergency organization.

1. THE LEGISLATIVE FRAMEWORK

The United Arab Emirates has recently established a legislative framework for emergency preparedness and response to radiological and nuclear events.

Federal Law No. 2 of 2011 established the National Emergency Crisis and Disasters Management Authority (NCEMA) under the Supreme Council for National Security and sets out its roles and responsibilities in building the United Arab Emirates' all hazards emergency management capabilities. The NCEMA's headquarters and the National Operations Center are based in Abu Dhabi and a coordination office is located in each of the seven Emirates.

The NCEMA's main roles and responsibilities as per Article 5 of the Federal Law by Decree No. 2 of 2011 include:

(1) Participating in developing and coordinating the strategic plan to manage emergencies, crises and disasters, including the response plans, and taking the necessary measures to implement them in cooperation with concerned authorities within the State.

(2) Supervising the development of national response capabilities through proposing and coordinating interagency programmes at the local and State level. These programmes should be updated regularly.
(3) Participating in preparing a register of risks and threats at the national and local levels, and updating these registers regularly in collaboration and coordination with the State concerned agencies.
(4) Managing emergencies, crises and disasters through coordinating and collaborating with State concerned agencies.
(5) Coordinating the roles of State concerned agencies during emergencies, crises and disasters.
(6) Participating in preparing and coordinating the necessary emergency plans for national critical infrastructure and following up the implementation of these plans in collaboration and coordination with the State concerned authorities.
(7) Participating in proposing and developing policies, safety measures, professional and institutional safety and security standards as well as plans and standards for business continuity in coordination with the State concerned authorities.
(8) Participating in the establishment of necessary criteria to evaluate procedures for managing emergencies, crises and disasters in coordination and collaboration with the State concerned agencies.
(9) Conducting the necessary scientific studies and research through the establishment of an information and resources centre focusing on matters related to emergencies, crises and disasters and predicting them and actions needed to respond to them, in coordination with the State concerned agencies.
(10) Participating in preparing, coordinating and implementing exercises related to the management of emergencies, crises and disasters, in coordination with State concerned agencies, and follow-up the implementation of them.
(11) Proposing legislation and regulations that provide for the management of emergencies, crises and disasters, and that establish the relationship between the NCEMA and the concerned agencies.

The Federal Law by Decree No. 6 of 2009 on Peaceful Uses of Nuclear Energy [the Nuclear Law], issued in September 2009, established the Federal Authority for Nuclear Regulation (FANR) as the independent nuclear regulator and empowers FANR to determine all matters relating to the regulation, inspection, and oversight of the nuclear sector with respect to nuclear safety, nuclear security, radiation protection and safeguards, including powers to set up and operate frameworks for emergency preparedness and response.

Especially, Article 49 of the Nuclear Law states that:

"1. The competent authorities and licensees shall establish measures for Emergency Preparedness and Emergency Response. 2. Emergency Planning measures shall be established:

(a) for protection of the population (off-site Emergency Plan), which regulates the Emergency Zones and determines the actions to be taken by the competent authorities to protect the population, property and environment in case of an Accident;
(b) for each Nuclear Facility and the facility that contains sources of nuclear radiations (on-site Emergency Plan), which determines the actions to be taken by the Licensee for Accident mitigation and remediation of consequences in co-ordination with the off-site Emergency Plan."

Moreover, Article 24 of the Nuclear Law specifies that the "License issued by the Authority (FANR) shall specify: … the Emergency Preparedness …". The regulation FANR-REG-24 on Basic Safety Standards for Facilities and Activities involving Ionising Radiation other than in Nuclear Facilities, issued by FANR, requires that the licensee prepares and maintains an emergency plan for protection of people, commensurate with the nature and magnitude of the risk involved. The emergency plan provided as a part of the licence application is reviewed and assessed by FANR as part of its review of the licence application. Licence conditions include requirements for incident reporting.

Finally, Article 7 of the Nuclear Law states that:

"The Authority (FANR) shall co-operate with the relevant government entities, advise them, and provide information on matters related to nuclear security radiation protection and security concerning following areas: … Emergency planning and Emergency Preparedness … ."

There is also an obligation on each licensee to notify, in particular FANR, in case of incident or security breach listed as a licence condition. These events may evolve to an emergency.

FANR has also been designated as of the competent authority for the United Arab Emirates for both the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. FANR is also the point of contact for the IAEA Incident and Trafficking Database (ITDB).

For robust cooperation and to make sure of an outstanding management for any event involving radioactive material in the United Arab Emirates, the NCEMA and FANR have signed a memorandum of understanding. In particular, it provides for ongoing liaison through regular meetings of a steering committee and creates a channel for training and shared exercises between the two organizations.

2. THE UAE NATIONAL EMERGENCY ORGANIZATION

The NCEMA, in collaboration with key national stakeholders, has developed the National Response Framework, which outlines the response arrangements for all types of emergencies identified in UAE National Risks and Threats Register. FANR, along with other relevant authorities in the State, participated in developing both the Risks and Threats Register and the National Response Framework by providing expert advice regarding nuclear and radiological emergencies.

Moreover, FANR is developing its capacity for responding to abnormal situations or events that involves radiological or nuclear materials. An emergency duty officer is appointed each week 24/7 to receive information and to manage it with the advice of an emergency manager. FANR is equipped with an emergency operation centre, which will, depending on the seriousness of the event, be activated. FANR is also establishing a radiological field team for verification and support if needed.

The Ministry of Interior and the Ministry of Health have already established organizations as well as the means to manage different types of emergencies from the local level to the federal level.

Finally, at the local level, licensees of regulated material (radioactive materials and radiation sources) have developed emergency plans following the requirement of FANR regulations.

For each type of event, a lead organization has to be defined, based on its experience, capabilities and training in dealing with hazard. This organization is to lead the planning team during the preparing and coordination of emergency plans, which relate to the relevant hazard and it may lead the implementation teams in carrying out such plans. The first responder — the first organization responding to the emergency — may not be the lead organization. When an event occurs, at the beginning only local first responders — police, civil defence or medical service — necessarily are involved but have also to alert, as soon as possible, federal authorities in order to be prepared to respond in case of an increasing threat.

Different types of events may involve regulated materials outside nuclear facilities such as:

- Medical exposure reported from hospital or medical facility;
- Discovery of a radioactive source or radioactive contamination;
- Missing radioactive source (lost or stolen);
- Unshielded radioactive source in a public place;
- Accident in the shipment of radioactive materials;
- Fire, explosion or similar event that may damage barriers or the container of radioactive material;
- Accident in a facility resulting in spill or contamination with radioactive materials;
- X ray machines and accelerators incidents (controls or exposure);
- Media and public inquiry regarding radioactive materials.

The organization to manage events involving regulated materials is to be adapted depending on the extension of its impact and the seriousness of its consequences for the health of the personnel and the public and the environment.

An event may only require to be dealt with by a local lead organization, supported by one or more local entities, or may require to be managed by more than one local entity and require resources and strategic directives by a lead organization. In this second case, the NCEMA will observe the situation and prepare to raise the level of emergency if the situation requires. Examples of such events are the discovery of a source or a contamination or the notification of the loss of a radioactive source.

However, a radiological event may also lead to potential significant consequences to health or to the environment and it requires national support and coordination by several federal entities to be dealt with. In this case, it is to be managed by the lead organization and its emergency centre using their resources and receiving strategic directives by the national emergencies and crises management team through the National Operations Centre at the NCEMA. A major accident during the transportation of radioactive material or a fire at facility containing such materials may need these types of organization and the mobilization at the federal level.

3. THE PAST EVENT

An event happened two years ago when a company licensed by FANR lost a projector used for industrial radiography containing an iridium source with an activity of 2.85 TBq. This type of source is considered by the IAEA as dangerous radioactive sources which, if not under control, could cause severe deterministic effects (Category 2).

The chronology of events was the following:

- On the night of 25 October 2011, after achievement of a non-destructive testing radiography, the device was loaded on a vehicle and shipped from the client area to storage area of the company, by passing through a resident area.
- On the morning of 26 October 2011, arriving at the storage area in Mussafah, the projector was no longer in the vehicle. After an unsuccessful search, the company reported the loss to the nearest police station.
- On 6 November 2011, a passerby discovered the device in the town of Al Rahba, located 30 km from Abu Dhabi/Mussafah.

FANR was informed five hours after the notification of the loss through its emergency number, and one hour after the alert, a combined FANR/Police team begun to search with the use of radiation equipment. In parallel, the NCEMA and Health Authority of Abu Dhabi (HAAD) were alerted.

The public and media were informed later by a press release posted on FANR's web site. The following days, search and survey with radiation equipment were conducted by FANR with the help of other agencies such as the armed forces in areas close to the journey.

On 6 November 2011, the police were informed of the discovery of the device. FANR confirmed on the spot that the device was not damaged or tampered with. FANR notified the IAEA, as the point of contact for the United Arab Emirates of the ITDB of both loss and recovery of the radioactive source.

Overall, this event was well managed with the strong cooperation among the NCEMA, the Ministry of Interior, especially the Abu Dhabi Police, HAAD, the armed forces, FANR and the licensee. This demonstrates the capacity for local and federal authorities to work closely together.

A few months later an exercise was organized by the Sharjah police to confirm the roles and responsibilities of response organization. This event was also used to improve the preparedness of the stakeholders to deal with future incidents. Early this year, the Fujairah police conducted an exercise to test the coordination with the concerned entities involved in radiological events.

4. CONCLUSION

The United Arab Emirates' organization in regards with the radiological emergencies has its legislative framework established and is in process of being finalized.

Depending on the extent of the impact of such event and the seriousness of its consequences to health of the personnel and the public and to the environment, the implementation of organization to deal with will stay at the local level, involving the licensee and local governmental entities or will rise to the activation of the national emergency organization. However, an event involving radioactive material or radiation source will not raise the potential consequences of an accident at a nuclear power plant. Beginning with the capacity and means to manage events from non-nuclear sector will allow the United Arab Emirates to build on and to be prepared in the future to deal with potential event at a nuclear power plant.

The past event of loss and recovery of a radioactive source was very helpful to implement the already defined organization at a local level and to test its effectiveness. The incident has also highlighted the importance of coordination between different governmental agencies in responding to such emergencies, which resulted in further cooperation and understanding between all stakeholders.

Future plans include conducting a series of drills and table top exercises for different scales and types of radiological and nuclear emergencies in order to test the plans and procedures that were drafted by FANR and other relevant authorities.

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SEARCH AND RECOVERY EFFORTS BY THE STATE OF TEXAS TO LOCATE MISSING RADIOACTIVE SOURCES

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Abstract

The paper describes the response by the State of Texas to three radioactive materials incidents: a stolen 1250 GBq iridium radiography camera source; a lost 555 GBq americium/beryllium well logging source; and a found 0.296 GBq ^{137}Cs and 1.48 GBq americium/beryllium moisture density gauge. Search and recovery efforts included extensive ground level detection efforts and aerial radiological surveys. Coordination with local, state and Federal entities included: the Texas Department of State Health Services Radiation Control Program; the Texas Division of Emergency Management; the local police and sheriff; the Federal Bureau of Investigation; the Texas Military Force's 6th Civil Support Team; the United States Department of Energy aerial surveillance; the United States Environmental Protection Agency aerial surveillance; state highway patrol; United States Customs and Border Protection; the State of California; the United States Nuclear Regulatory Commission; and the specific licensees who owned each source.

1. INTRODUCTION

In Texas, an 'Agreement State', the regulatory authority for radiation producing machines and material falls to the Texas Department of State Health Services, referred to in internal documentation as 'the Agency' or 'DSHS'. When sources are lost or stolen, the DSHS is frequently the first point of contact for those members of the public who are involved. National security concerns, local authorities and environmental agencies also have an interest in locating lost sources of radiation.

The DSHS receives incidents referred from other agencies and entities, including local law enforcement or Federal agencies. This also requires effective coordination. Described here are three incidents where significant coordination was required between the DSHS and other local, state and Federal authorities.

2. SOURCE RECOVERY EFFORTS

2.1. Stolen radiography camera (I-8871)

A radiography camera, containing a 1250 GBq iridium source (see Fig. 1) was stolen from a radiography truck in a hotel parking lot on the morning of 19 July 2011. The DSHS was first made aware of the theft when it was reported that morning by the radiography company. Local law enforcement was contacted and responded to the scene. The DSHS notified the Texas Association of Pawnbrokers and the Institute of Scrap Recycling Industries. It is not uncommon for expensive looking equipment to be stolen without the thieves' full understanding of its radiological nature. These pieces of equipment are sometimes dumped or sold to pawn shops and scrapyards.

The call service employed by the DSHS takes initial information during off hours, and then calls the appropriate agency personnel until someone is contacted. The call service made contact with A. Tucker, an incident investigator at the DSHS, who proceeded to notify the United States Nuclear Regulatory Commission's (NRC) Headquarters Operations Office (HOO). For events involving certain types of equipment or certain levels of activity, immediate reports to the HOO are required.

That morning, R. Jisha, an incident investigator at the DSHS, was dispatched to the location — an Austin area hotel parking lot. At around this time, the United States Department of Energy (DOE) called and offered their assistance. They were given activity and dose rate information to begin their processing. R. Jisha conferred with the radiographers and the Austin Police Department (APD). The APD was able to identify the thieves' vehicle type via security tapes. The theft had occurred between 04:00 and 04:09 that morning. Fingerprints found at the scene did not match any searchable database entries.

Investigation revealed that while the dark room in the back of the truck was locked, the tailgate had not been locked, according to the radiographers. Further, the mounting on the cable used to lock the gauge's box to the truck was weak enough that it could be worked free without cutting or unlocking the cable. The alarm was tested and found to be in working condition. However, it had not been set the night before, and therefore could not prevent the theft. Other equipment, such as the cables and tubes used to operate the camera, was also stolen.

Later that day, the Federal Bureau of Investigation (FBI) was contacted by the DSHS. They had been previously contacted by APD and were aware of the situation. At this point, a press release was created. Local hospital groups were directed to the DOE training on biological effects of radiation and to the Radiation Emergency Assistance Center in Oak Ridge, a national resource on radiation injury.

FIG. 1. Missing radiography camera model.

Meanwhile, drive-by searches for the camera were being conducted by the radiography company, the DSHS, and by the 6th Civil Support Team (6CST), with high priority for government buildings. Local entities, such as the Texas Department of Transportation, Austin Crime Stoppers and Keep Austin Beautiful, were advised to call in if anyone found the camera. United States Customs and Border Protection (CBP) was notified to be on the lookout for a radiography camera being secreted into Mexico. Further, contact was made with a representative of the Department of Homeland Security assigned to the incident.

The source (SPEC) and camera (QSA Global) manufacturers were contacted about the theft. While there was a locking mechanism associated with the camera, every key for that camera model would work. Further, the lock would be easily replaceable. The manufacturer stated that they would be on the lookout for requests for replacement lock assemblies. While replacement sources normally only involve a licence check, the camera serial number would be monitored for at service facilities, including those in Mexico.

On 25 June, a conference call between the DSHS, the DOE, the NRC and the DOE National Nuclear Security Administration Radiation Assistance Program (RAP) occurred. It was determined that a flyover would be conducted with the RAP fixed wing detector aircraft. This aircraft flies a particular route and can be useful in locating sources along its path, provided there are no shielding or other issues.

Meanwhile, the APD suggested using one of its helicopters as a secondary aerial search vehicle. A detector array from 6CST was used in the helicopter. Both aerial searches occurred on 27 June, but did not detect any points of concern (see Fig. 2).

Other states were contacted and given information regarding the incident. In subsequent months, a few landfill loads sparked further investigation, but did not ultimately relate to the stolen camera. A seemingly unrelated attempted radiography truck break-in had occurred in Louisiana a few days after the one in Austin. However, it appeared to be local teenagers that had confused it for a seafood truck. In that case, a properly set alarm had thwarted the break-in. Unfortunately, the stolen camera has still not turned up.

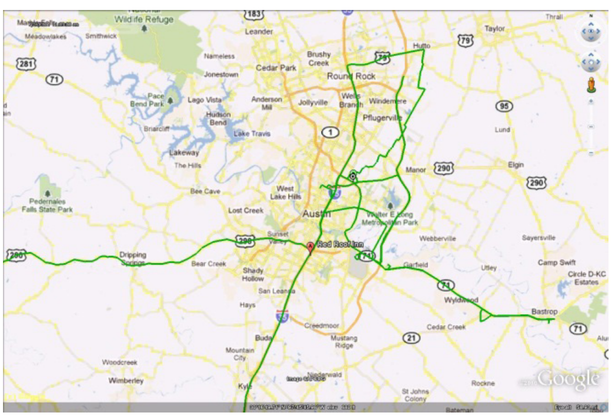

FIG. 2. Flyover search routes.

A radiographer and the licensee itself were both cited for security related violations as a result of the Austin incident.

2.2. Lost well logging source (I-8988)

On 11 September 2012, a 555 GBq americium/beryllium well logging source was discovered missing by its crew working around the Pecos, Texas, area (see Fig. 3). The source was found to be missing once the crew arrived at another site near Odessa, Texas, 130 miles away. As the well logging crew prepared to do their work, they saw that the transport container (or pig) did not have the plug inserted and that the source was missing. Upon discovering this, one of the crew returned to the well site near Pecos and searched, but did not find the source.

The DSHS was notified that same evening. The lock and source plug were lying in the pig compartment. The radiological safety officer (RSO) contacted local law enforcement, including the sheriff's department and state police, and agreed to send a copy of dose readings to the DSHS, which, in turn, notified its local inspectors, as well as the NRC HOO.

The DSHS again collaborated with 6CST to perform drive-by searches. A road based search of the route was to be conducted at approximately 20 mph. Tests of the equipment using a similar source used showed good readings at 35 yards from the test source at this speed. A state highway patrol trooper was arranged as an escort for the search procedure. During the testing of 6CST's equipment, the FBI was contacted. The special agent consulted did not believe any criminal activity had taken place.

FIG. 3. Example americium/beryllium source, identical in appearance to lost source.

Though the search took around ten hours and covered the path reported by the crew, the source was not located. The next day, the Airborne Spectral Photometric Environmental Collection Technology (ASPECT) plane from the United States Environmental Protection Agency arrived and made a sweep of the route. Unfortunately, while it identified a few possible locations, it did not ultimately find the source. Rains the previous day had filled roadside ditches with water. Just a foot or two would likely have shielded the source enough to keep it from being located by the plane's detectors.

Interviews of the well logging personnel were conducted on 18 September. A. Tucker and C. Moore of the DSHS conducted these interviews with each of the three crew members and with two previous members of the crew. Each of the crew members drove one of the vehicles to each location. The source was discovered missing when the source holder tool would not engage the source inside the pig at the second site.

Unfortunately, the crew was largely new. While the crew lead was an experienced well logger, one worker had only been on the job for five months, while another was substituting that very day. Further, the substitute had only thus far worked on open well logging. This contributed to the general disorganization of the crew, and perhaps a more experienced and personally familiar crew could have avoided the situation. In later interviews that more experienced well loggers expressed doubt as to whether one could notice whether or not the source tool had the source in it. Additionally, the substitute was somewhat inexperienced in the use of the survey meter. As he was the one that performed the final survey of the truck before heading out from the Pecos site, the incident would have been avoided with more training on performing surveys.

Furthermore, all but one of the four bolts intended to secure the pig to the truck were missing. The pig could be slid back and forth in its compartment, and indeed was frequently slid sideways so that the door was easier to close and lock. When the source was found to be missing, the pig could be pried up enough to check underneath. Additionally, a pin used to keep the pig door secured was missing. As mentioned earlier, the lock intended to keep the pig plug in was found lying inside the compartment. Another lock normally used to secure the source compartment was missing from the truck entirely. Later in the interview, one worker stated that the pig door could not be locked at all. Finally, the threads inside the pig intended to hold the source in place and help remove it from the source tool were stripped. The workers indicated that they had to be careful removing the source tool from the pig, as the source could easily slip out without the threads.

Lastly, it was common practice for the crew leader (logging engineer) to lend his badge and key to his crew members to go and get a logging source while he stayed in the office and finished paperwork. While sources used for well logging are somewhat strong, they are not normally by themselves increased control quantities. However, the practice at the site was to store all sources in a single source pit, with a single key being able to unlock each and every source. Aggregated together, these sources did make up an increased control quantity. While the crew leader and the regular crew worker that was substituted were authorized for such access, the other two were not. That morning, the other two crew workers had retrieved the source from the pit without supervision of the logging engineer.

Other well logging outfits working in the area were contacted and told to keep an eye out for the missing source. Local hospitals were also contacted to keep them on the lookout for radiation related injuries. As the landscape was drying out, a further ASPECT run was planned, with a test performed involving a similar source. Without water to interfere, the detector easily spotted the test source.

On 4 October, the source was found by a member of the general public. The individual that found the source was a worker from a pumping service company, who was picking up trash along the roadway. While he did pick up the source with his hands momentarily to throw it in the back of his truck, it appears that he did not receive a high enough dose to produce injury. Doses were estimated at 1 R for the hand and 85 mR for the whole body, including transport time. When it was established that this was the missing source, he was then told by the RSO of the well logging company to put it in a steel box and to meet him in the parking lot of a grocery store to deliver the source. He was not instructed to provide any labelling or other considerations for the tool box the source was put into.

The location that the source was found on the roadside was roughly 8 miles west from the route described by the well logging crew and not covered by the earlier ground and air surveys (though the precise location on the road could not be recalled, see Fig. 4). To date, the reasons for the source being found so far out of the way are unknown. While the well logging trucks were equipped with a black box with Global Positioning System ability, it was at the time only set up to record points where sudden stops or starts were made and where certain speeds were exceeded. The well logging crew could not have gone in that direction without significant time lost. A theory that the source may have become lodged in the wheels of a road grader proved infeasible. No mysterious radiation injuries to other members of the public who may have moved the source have so far been reported. A number of citations resulted from this event, including the logging engineer and the licensee.

FIG. 4. Path travelled by well logging truck and approximate location of found source.

2.3. Found moisture/density gauge (I-9038)

On 28 January 2013, a trailer set off a radiation alarm at a CBP checkpoint. The trailer was full of personal belongings, with the owner moving house from California to Texas.

CBP contacted the DSHS to report that agents at the checkpoint had identified the source as being ^{137}Cs and some kind of neutron source, isolated to the front area of the trailer. The owner of the trailer stated that he did not have a licence for radioactive materials, and that the only thing he could think of that could be radioactive was a “tool for finding underground pipes” he had bought at a swap meet the year before for approximately US $150.

After conferring with CBP agents about dose rate readings, it was determined that the trailer could be unpacked so that the object could be removed. Based on pictures sent to CBP by the DSHS, it was confirmed that the object was a Troxler Model 3430 moisture/density gauge (see Fig. 5). G. Gurnee, a DSHS inspector from El Paso, was dispatched to the location that afternoon. The owner of the trailer willingly surrendered the device, and it was impounded.

Through the NRC’s Nuclear Material Events Database, it was determined that the moisture/density gauge was one that had been stolen in 2006 from a licensee in California. Once it was confirmed with California Radiological Health that their licence was still current, the original owners were contacted and a licensed service company picked up the gauge from the DSHS. No citations resulted from this event.

FIG. 5. Troxler Model 3430.

3. CONCLUSION

While the radiation control programme in Texas does have considerable resources, it is our ability to coordinate with other agencies that provides much of our large scale operational capability. When radiation is involved, other entities are eager to help in any way that they can, and recent efforts to streamline interagency cooperation have proven useful. Relationships with other state radiation programmes, Federal entities and local law enforcement agencies have made conducting incident responses easier and helped in getting the proper information quickly.

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MEETING THE TECHNICAL, MEDICAL AND FINANCIAL CHALLENGES OF DAMAGES CAUSED BY RADIOACTIVE SEALED SOURCES*

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Abstract

Sealed sources are used extensively in a number of fields, including industry, oil exploration activities, research, medicine and agriculture. Despite excellent records over the past 50 years, accidents involving radioactive sources occur. The paper is aimed at reviewing their implications as well the liability for damages arising from them.

A sealed radioactive source is radioactive material that is (a) permanently sealed in a capsule or (b) closely bonded and in a solid form [1]. Depending on their purpose, sealed sources can have very different level of radioactivity concentration and, consequently, can present different levels of hazard. The IAEA has developed a categorization system for radioactive sources to provide a risk based ranking of radioactive sources and practices [2]. Five categories are recognized, with Category 5 being the less dangerous. So for example, the average activity of americium sources used in some smoke detectors is less than 40 kBq and these sources are ranked in Category 5. On the other hand, treatments of patients for carcinoma with a high dose rate remote control after loading machine require typically ^{192}Ir sources with initial activity of 3.7×10^{10} GBq, which are Category 1 sources.

On the basis of this categorization, risk informed decisions can be made in a graded approach to the regulatory control of radioactive sources for the purposes of safety and security. Several standards guidance and codes have been developed by the IAEA to assist Member States in developing their national regulatory framework to protect workers and the population against the risks

* The author alone is responsible for the facts and opinions expressed in this article. The views expressed are those of the author and do not necessarily represent those of any organization he may be affiliated with.

posed by the radioactive sealed sources. The Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [3], approved by the IAEA Board of Governors and General Conference in 2003 and 2004, describes how States can safely and securely manage high risk radioactive sources. To date, 117 States have made a political commitment with regard to the Code of Conduct (see para. 6, B. Code of Conduct on the Safety and Security of Radioactive Sources, of Ref. [4]) and 81 States with regard to its supplementary Guidance on the Import and Export of Radioactive Sources [5]. IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS) [6], details the requirements for the protection of people and the environment from harmful effects of ionizing radiation and for the safety of radiation sources. Both documents set the key principles for regulating the use of radioactive sources through their life cycle. The BSS details the responsibility of producers and suppliers of radioactive sources, stressing the importance of good design and a high manufacturing quality. The main responsibility for the safety of the use sources is, however, placed on registrants and licensees, in the framework of a national legislation and regulation, which introduces a regulatory body. The latter should establish an effective licensing system for sources, following a graded approach: some sources with very low risks can be exempted from any licence or registration and some other will be required to be covered by a licence with stringent conditions.

The implementation of the Code of Conduct and IAEA safety standards has resulted in significant improvements over the safety and security of radioactive sources worldwide. Despite this progress, accidents and incidents continue to occur resulting in many cases in serious damages. It is estimated that more than 600 radiological accidents are known since 1945.

The world reference of what could happen with a disused high risk source out of regulatory control is the accident which occurred in 1987 in Brazil [7, 8]. A radiotherapy caesium chloride source was stolen from an abandoned hospital site in the city of Goiânia. After the source had been opened, a significant release of radioactivity occurred, causing the deaths of four people, while nearly 300 suffered radioactive contamination and about 112 000 had to be examined. In the cleanup operation, topsoil had to be removed from several sites, and several houses were demolished. Ultimately, the cost from six months of intensive cleanup, especially within a 1 km^2 area, during which seven houses and several buildings were demolished, amounted to US $27.2 million. However, the indirect costs due to negative economic repercussions were estimated to be in the hundreds of millions of dollars [9, 10]. According to IAEA Director General Yukiya Amano, Goiânia is “one of the world’s worst radiological incident” and the “best real-world indicator of what could happen on a larger scale if terrorists were to detonate a dirty bomb in a large city or at a major public event” [11].

The Goiânia accident resulted from a high risk source being abandoned. But there have been also several accidents with sources in use which have resulted in severe consequences, in particular in the field of industrial radiography. Industrial radiography is a non-destructive testing method using X ray or gamma radiation to investigate the integrity of equipment and structures such as vessels, pipes, welded joints, castings and other devices. The equipment required is relatively inexpensive and simple to operate. It may be highly portable and capable of being operated by a single worker in construction sites, offshore locations and cross-country pipelines as well as in complex fabrication facilities. When the practice generally poses a negligible risk on the public and low occupation radiation exposure, experience shows the high level of associated hazards when the working practices are not safe [12].

Several accidents with gammagraphy equipment have occurred in the last ten years, sometimes resulting in very high exposure of workers and severe radiological burns. While consequences for the victims can be very important, no mechanism is generally in place to compensate them. Under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the IAEA was requested for medical assistance by several States. In many cases (Peru 1999, Panama 2000, Chile 2005, Senegal 2006, Tunisia 2007, Ecuador 2009, Bolivarian Republic of Venezuela 2010, Bulgaria 2011 and Peru 2012), patients suffering from severe radiation damage after a gammagraphy accident had to be sent abroad for medical management.

The medical management of irradiation accident made significant progress over the last ten years. A multidisciplinary team from the Percy Military Training Hospital, in Paris, France, the Military Blood Transfusion Centre (Centre de transfusion sanguine des armées) and the Institute for Radiological Protection and Nuclear Safety (Institut de radioprotection et de sûreté nucléaire) has developed a unique experience in this field, including rapid tools of dose assessment, advanced strategies for the medical management of mass radiation exposure and treatments combining stem cell therapy and surgery, which constitute a medical breakthrough. This advanced medical management of irradiation accident shows very good results but is cost extensive: for example, the cost of the treatment in France in early 2012 of a South American patient highly exposed during an gammagraphy accident was estimated at about €150 000. No mechanism is in place to cover these costs and funding solution have to be found by the IAEA on a case by case basis, very often through the donation of some of its Member States.

Beyond consequences as regard as loss of lives and personal injury, damages resulting from the use of gammagraphy devices can also be material. Over the past three years in France, there have been five reported incidents of disconnected or blocked sources resulting from radiography devices' failures[1]: these events cannot be considered as 'accidents', as there is generally no emergency and no victim suffering from exposure. The source is outside of the device and if adequate preventive measures such as safety perimeter around the source are properly implemented, the radiation risks can be easily managed to avoid human exposure. However, the operations to recover the source can be very complicated, very often involving automated or robotic systems and the safety perimeter can meanwhile be very large, due to the high level of radiation around the source which justifies the use of high technologies (robots), thorough safety analysis and adequate authorization from the regulatory body. When the accident occurs in the framework of a subcontract with a radiography company, it can also have significant consequences on the economical activity of the ordering company, as some examples show:

(a) One incident occurred at the Électricité de France nuclear power plant of Blayais in March 2012. A 2.4 TBq ^{192}Ir source disconnected when using a radiography device. About three weeks were necessary to recover the source, delaying numerous maintenance operations and inspection programmes during the shutdown of the reactor.

(b) A similar incident occurred in June 2012 in an oil refinery with a 2 TBq ^{192}Ir source in the south of France, where three weeks were also necessary to organize the recovery operation. During the elapsed time, a large standoff distance through a safety perimeter had been established, which had a significant impact on the activity on the industrial site.

(c) An incident occurred in September 2011 in a very small company producing pipes in the east of France, where a big metal part had fallen on the cable of the device during radiography operations, causing malfunction of the device. In that case, the initial safety perimeter around the 500 GBq ^{192}Ir source entirely paralysed the activity of the pipes company, causing significant operating loss and temporary lay-off of personal. After two weeks, the perimeter could fortunately be reduced through the cover of the source with lead bags to reduce the economical damage, giving more time to organize the recovery operation, which was finally organized two months after.

In all three cases, a very interesting feedback from experience was drawn by the French Nuclear Safety Authority (ASN, Autorité de sûreté nucléaire) with the

[1] Many authorities have reviewed this kind of problems with radiography devices. See, for instance, the recommendations in Ref. [13].

different stakeholders to improve the reactivity in such cases and to identify more standardized process of intervention. To organize feedback from experience at international levels on management of such a situation would be of great interest, as cases of disconnected or blocked sources are very common in gammagraphy activity. In all complex situations of source disconnects or blockings, the liability for economical loss remains a recurrent challenge.

Radiography devices are also sometimes used in bunkers by companies with an activity requiring often industrial radiography (steel part industry for instance). The activity of the radiography sources can then be very high, but the location of the source in a bunker offers greater protection for the workers, at least in theory. However, when a source cannot be put back in the block of lead or depleted uranium shielding, whatever the reason is, it is still very difficult to recover it due to the very high radiation rate around the source.

As an example, a ^{60}Co source from a malfunctioning radiography device has been blocked in the bunker of a steel company in the east of France since October 2010. The recovery operation would require the use of robots and the design and manufacture of ad hoc tools, so that the cost is estimated to be a few hundred thousand euros. The company, which has some financial difficulties, cannot afford the cost, so the source has not been recovered yet.

A final incident example highlights the potential damages in case of failure when using a source or when recovering it. In May 2010, a French company manufacturing large steel parts for the automobile and train industry reported a failure of a radiography device using a 1.25 TBq ^{60}Co source in a bunker. It was impossible to move the source back to the shielding cask, even after an intervention of the device manufacturer. A technical support organization was mandated by the manufacturer to recover the source with robots, which were supposed to saw the cable and then put the source in a cask. An error occurred in the localization of the source so that the robot sawed the source itself. As the source was originally a sealed one, no confinement measures had been taken during the preparation of the recovery operations. As a consequence, the ^{60}Co powder spread through the whole factory, contaminating not only the bunker but also largely the storage room of the company (see Fig. 1).

Fortunately, the sanitary consequences to workers were negligible, but 7200 items of equipment were contaminated, paralysing the activity of the whole company for months, until the mechanical equipment could be cleaned up, at a cost of about €20 million. This situation led the company almost to bankruptcy, as the contract to deliver steel parts to the automobile and train industry could not be fulfilled. The cleanup of the whole factory can be estimated at several tens of million euros and last several months. The total economic loss for the company has not been estimated, but it is very significant. This case is an interesting one in terms of legal responsibilities, as three stakeholders were involved in the

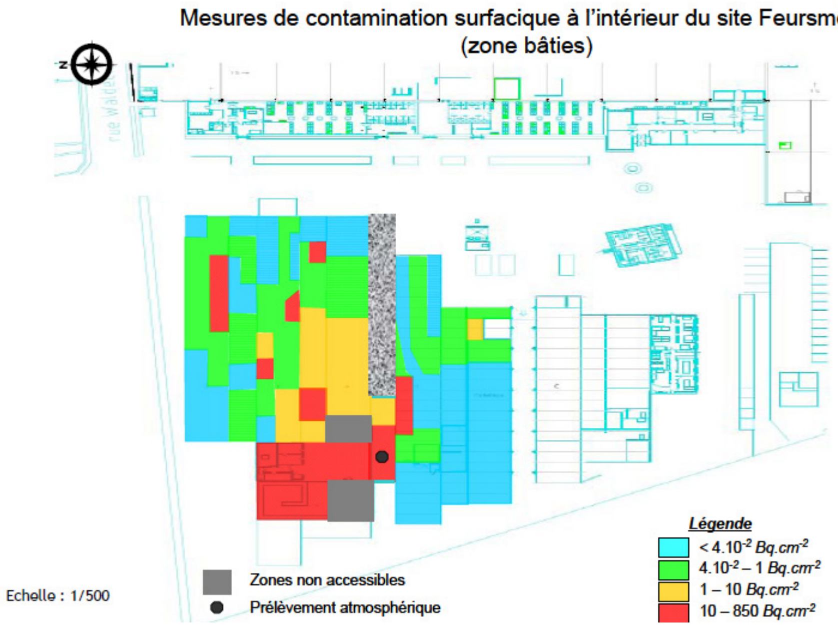

FIG. 1. Contamination map of the warehouse.

accident: the steel company, the manufacturer of the device, which intervened without any formal contract signed with the steel company but which had subcontracted with the technical support organization for the recovery operation with robots. The important economical consequences of this event have led the ASN to regulate much more stringently the recovery operations of gammagraphy sources. A licence for such operations is now systematically required and only delivered if the application contains a thorough risk analysis.

Although the last 50 years show an excellent record in the use of radioactive sealed sources and although the regulatory control of these sources have made significant progress, accidents happen all over the world, resulting in damages to individuals and to companies. In such cases, liability is then a fundamental point for licensees, subcontractors and manufacturers of source devices. Which liability mechanisms could be put in place to cover more easily the costs of potential damages arising from the use of sealed sources?

Nuclear liability conventions have been adopted since the 1960s to strike a right balance between the unprecedented levels of risks and liabilities arising from nuclear installations and the social and economic benefits provided.[2] The radiation damages caused by the use of radioactive sources has been excluded from the international nuclear liability instruments under the rationale that the use of radioisotope, as the use of X ray equipment, does not present risks comparable to those arising from nuclear power plants or from nuclear transport, for which the conventions were designed. In particular, no transboundary consequences can be expected from any accident with radioactive sources. The result is that incidence of radiation damages from radioactive sources is not covered neither by any international instrument[3] at that stage nor by special liability laws at the national level. In light of the given examples, the situation is not satisfactory, as the treatment of irradiated victims very often requires immediate funding and as the absence of financial guarantee for liability can in some cases endanger the financial stability of companies when their activity is suspended pending the recovery operation of some radioactive source.

The extension of the international nuclear liability regime to the use of radioisotopes would be very difficult to envisage, as it requires formal amendments of the related conventions, and it is probably not desirable: some principles of the nuclear third party liability regime would not be adapted to the economic context of the use of radioactive sources. The most central principle of this regime, unique in the field of nuclear law, is that the nuclear operator is exclusively liable for damage arising from accidents occurring at its installation or during the transport of nuclear substances to and from that installation. This principle of channelling of nuclear liability would be difficult to apply to industrial radiography. The industrial radiography companies, which are the operators of the devices, generally operate on industrial sites of their clients and they have very little control on their work environment. Moreover, they are very dependent from the devices' manufacturers and sources providers: when the device is out of order, the licensee generally has not the competences to intervene without the help of the manufacturing company or technical support organization. Finally, the international nuclear liability regime only worries about third part liabilities and would, in case of extension, only cover cases like Goiâna, where there are no contractual relations between the licensee and victims.

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[2] Vienna Convention on Civil Liability for Nuclear Damage, of 21 May 1963, amended by the Protocol of September 1997; Paris Convention on Third Party Liability in the Field of Nuclear Energy, of 1960, as amended, and the Brussels Supplementary Convention on Third Party Liability in the Field of Nuclear Energy, of 1963, as amended; Convention on Supplementary Compensation for Nuclear Damage, of 1997, not yet entered into force.

[3] Sealed sources are also exempt from the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

The establishment of a dedicated international liability regime would be of course a possible solution, but we can nevertheless have some reasonable doubts about the willingness of the international community to invest energy in the drafting of a new convention in that field. The number of accidents with radioactive sources remains low and their consequences, even if they can be dramatic for victims or some companies, are probably too local to be considered as a global challenge.

The IAEA is well aware about the need to improve the funding of the management of emergency situation. When an accident with high activity sources occurs and when people get irradiated, efficient medical management of the situation requires reactivity. When highly irradiated, the victim has to be transported to a hospital with adapted competences within a limited number of days, as one symptom of acute irradiation is haematological ones. This is a very high constraint for the Incident and Emergency Centre of the IAEA, as its staff has to identify funding to cover the medical management of the patient very quickly. This difficulty has been several times discussed through the IAEA Response Assistance Network (RANET),[4] and it has led to consider the establishment of a fund in the IAEA to cover the costs of the treatment of patients in case of emergency. Such a fund could be designed to receive up to about €300 000–400 000. The availability of such a fund would of course be an improvement, but its establishment would not solve the problem of the identification of the origin of the money. Even if a Member State were to accept making an extraordinary contribution for the establishment of the fund, it would be probably difficult to identify new donors after each use of some part of the fund. A possible solution could be to introduce this fund in the normal annual budget (up to €400 000 for instance) and to reallocate the money at the end of the year in case the fund has not been used for an emergency situation (i.e. to finance some improvements of the RANET network or to finance regional workshops or trainings on emergency preparedness and response).

An emergency fund would be nonetheless a very partial answer to the liability challenge set by high activity sources, which requires a much more generic answer. Another simple but generic option to consider could be to require through the licensing system an insurance to cover potential damages related to the use of the source. Nuclear damages are very often excluded of generic insurance policies, but the introduction of an obligation in the licensing system

[4] The major objectives of RANET are: to strengthen the IAEA's capability to provide assistance and advice, and/or to coordinate the provision of assistance as specified within the framework of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; and to promote emergency preparedness and response capabilities for nuclear or radiological emergencies/incidents among IAEA Member States.

would create a new market for insurance companies: the number of accident is quite low in comparison of the number of licensees and probabilities of their occurrence can easily be calculated. The risk should consequently be easily estimated by insurance companies, which should probably be in a position to make some offers. Insurances would not cover the costs of recovery operations but could at least probably cover the costs of medical management of victims and cover third party liability. Several States require licensees to lodge a bond to cover the cost of end-of-life management of a source: when licensees are required to make a financial commitment for proper end-of-life management, it would be logical to require them to improper end-of-life management resulting in injury or economical loss.

The liability challenges for damages in the case of event involving high activities sources should be obviously further reviewed by the international community, when considering the economic implications of some past events. A legal study of the issue should probably be conducted before opening discussion among IAEA Member States. The International Expert Group on Nuclear Liability was established in 2003 by the IAEA Director General to serve three major functions, namely:

- To explore and provide expert advice on general issues relating to nuclear third part liability and the need to develop further the IAEA nuclear liability regime;
- To promote global adherence to this regime;
- To assist Member States in developing and strengthening their national legal frameworks related to nuclear liability.

Even if this group was originally designed to work on nuclear third part liability for damages arising from the nuclear industry, it could probably provide some interesting input to the discussion on liability for radioactive sources. Some other discussions could be initiated within the IAEA to review with insurance companies which liability could be potentially covered by insurance policies.

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ANALYSIS OF TEN YEARS OF INSPECTION INTERVENTIONS

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Abstract

From 2001, the Slovenian Nuclear Safety Administration (SNSA) has been building a comprehensive system to establish a control over sources in Slovenia as well as to act in emergencies or safety or security events involving radioactive sources. The SNSA Database of Interventions includes altogether 144 events (i.e. cases) from the period 2002–2011 in which SNSA inspectors were involved. Although each case shows some particularities six typical scenarios are identified. Their analysis enables not only improvements of regulatory activities to prevent such events but also gives opportunities to upgrade the emergency response system in the State. The system requires identification of locations or institutions where safety and security of sources can be jeopardized, for example abandoned factories or research laboratories, installation of measuring devices and preparation of procedures of all institutions involved in recovery of a control over sources. The activation of SNSA inspectors is followed by risk assessment and by involvement of others who play a role in the recovery procedure (e.g. qualified experts, the Agency for Radwaste Management, the police and authorities from neighbouring States). The system is very flexible in order to cope with unforeseen particularities. The database shows that around 50% of interventions were related to scrap metal and around 30% to radioactive waste.

1. INTRODUCTION

After the discovery of ionizing radiation and radioactive materials at the end of the nineteenth century, sources of ionizing radiation became widely used, including in some consumer products. Looking back from the perspective of knowledge available today, the use of sources was not always justified, and moreover, regulations preventing unjustified exposure or contamination of people or the environment very often did not exist. As a result, many sources existed and exist even today without a proper control from cradle to grave. Some are related to long lived radioisotopes which were not taken into account when put on a market, such as ^{241}Am and ^{226}Ra. Radioactive sources pose a risk if abandoned. Moreover, they pose a very specific threat if used in malevolent acts.

Although the general public is mainly focused only on the risk posed by nuclear power plants, where material is actually as a rule strongly controlled, many other sources can pose significant risks. The IAEA Dijon Conference, which took place in 1998, has already focused on all sources [1].

In the last decade, all over the world nuclear regulatory authorities strengthened a control over radioactive sources in order to prevent unintentional exposure of people, contamination of the environment and substantial financial burden. The control is a global issue because very often sources are relatively small objects which can be transferred without any specific preparation from one State to another, as given, for example, in Ref. [2]. In addition, contamination posed in one State can cause contamination in a wide area (i.e. beyond the borders of the State affected), as evident from the unintentional melting of ^{137}Cs source in a stainless steel factory in Spain in 1998 [3].

International as well as national organizations started with many initiatives to tackle the safety and security of sources — for example, from publishing guidelines and recommendations [4–6] to preparing legislation such as Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS Directive) in the European Union [7]. In addition, international meeting and conferences were organized [8].

As a result, systems to prevent or enable malevolent acts were strengthened in parallel to strengthening a control over sources in order to prevent unintentionally risk posed by abandoned sources. Generally, such sources exist at the end of a lifetime cycle of a source. The experiences also show a third possible threat. Namely, even a member of the general public can pose a risk with relatively small quantities of radioactive material if no appropriate education or information is available, as evident from the events described in Refs [9, 10].

One of the main component of a strengthening safety and security of the sources is a prompt action in case of an emergency. Especially after the events of 11 September, the national emergency systems were largely revised taking into account also a possibility of a terrorist attack. Today, a few international emergency systems are available, such as IAEA Unified System for Information Exchange in Incidents and Emergencies and the 24 hour European Community Urgent Radiological Information Exchange (ECURIE) system within the European Union [11]. They enabling prompt information exchange in case of any radiological emergency. Some of the systems also enable a help provided to a State affected — for example, Radiation Emergency Medical Preparedness and Assistance Network (REMPAN) and the International Food Safety Authorities Network (INFOSAN).

2. BUILDING A REGULATORY SYSTEM IN SLOVENIA

In 2002, a new basic law related to safety and security of sources was adopted in Slovenia — the Ionizing Radiation Protection and Nuclear Safety Act — replacing the old act from 1984. The new act not only introduced updated safety requirements but also introduced a new regulatory framework including different institutions. The Slovenian Nuclear Safety Administration (SNSA) became responsible for a control over radioactive waste in the State. In addition, it also became responsible for the control over all sources, except for sources used in medicine. The legal background for managing safety and security of sources was later updated by numerous and comprehensive legal system. One of the legal acts is dedicated to a control of all scrap metal in the State in order to prevent the melting of sources [12]. The experiences with the melting of sources which happened in the past in the State, analysis of border crossing procedures concerning scrap metal as well as a study of a trade with such materials resulted in strict requirements. The operators of scrap metal yards have to establish a monitoring system at their premises and activate the SNSA in case of findings of orphan sources. Figure 1 shows a typical portal monitor system at a factory in use for years and a modern system at a scrap yard.

In 2004, Slovenia joined the European Union, adopting, among others, all legislation related to sources of ionizing radiation, which is based on the Euratom Treaty. The details of legislation related to ionizing radiation are given elsewhere [13]. The HASS Directive is specifically focused on:

— Identification of high activity sources in the State;
— State campaign to identified sources without a control (i.e. orphan sources);

FIG. 1. Portal monitor systems in order to identify uncontrolled sources at an entrance of a factory (left) and at a scrap yard (right).

— Identification of all sites where orphan sources can enter a State;
— Emergency system.

The system built in Slovenia is based on two main components, namely:

(a) Prevention activities;
(b) Emergency system including the SNSA inspection system.

Numerous preventive activities include, among others:

— Regular updating of a State registry of sources;
— Regular inspections of companies handling high activity sources;
— Preparation of leaflets with information about lost sources;
— Regular meetings with institutions involved in safety and security of sources (e.g. qualified experts, customs, police, Agency for Radwaste Management (ARAO, Agencija za radioaktivne odpadke) and scrap yard managers);
— Informational letters to managers of bankruptcy;
— Studying experiences from other States — for example, experience feedback on radiological incidents (RELIR, Retour d'expérience sur les incidents radiologiques);
— Connection with regulatory authorities of neighbouring States.

The details about preventing actions are given in Refs [14–16]. Both components mentioned can be strongly interrelated, for example if contamination or nuclear material is found during a preventive inspection the site is secured immediately and further strict procedures follow.

3. EMERGENCY SYSTEM IN CASE OF AN EVENT WITH A SOURCE

In order to systematically take lessons to be learned from each intervention of SNSA inspectors, the SNSA Database of Interventions was prepared. In the period 2002–2011, a total of 144 cases were identified, showing that on average one intervention (i.e. event) occurred per month. The events related to the only one nuclear power plant in the State are not included in the database. Interventions became an everyday part of an inspector's job. From the database, it is evident that nearly every event shows particularities. The emergency system needs to be able to tackle them. In general, the system to handle an event has four general components although all components are not present in each intervention:

(1) Identification of an event (e.g. a presence of a uncontrolled source or contamination);
(2) Analysis of a situation by the SNSA (e.g. inspectors perform on-site inspection);
(3) Recovery of a control over source or radioactive waste as appropriate (e.g. by technical support organizations (TSOs), customs, authorities of neighbouring States and ARAO);
(4) Final disposal of a source or waste, if appropriate.

3.1. Identification of an event

The identification of event and activation of the SNSA is as a rule based on a phone call about the uncontrolled situation, such as a fire related to radioactive material, spillage of radioactive material and identification of a presence of uncontrolled unknown source. The phone call can be done by users of sources, customs, other companies or institutions as well as by a member of the general public. According to legislation, all users of ionizing radiation sources are obliged to inform a regulatory authority in case of any event which might jeopardize the safety or security of sources. An identification of the presence of uncontrolled sources is also very often the subject of routine screening performed by portal and hand-held instruments or a result of a State campaign to identify uncontrolled sources.

Scrap metal yard managers, factories handling scrap metal, international harbours as well as some border crossings, including railway border crossings, are equipped by the instruments. All involved in searching for a source within scrap metal also use protocols regarding subtraction of natural background as well as checking of measurements, documentation procedure and reporting. As a rule, after identification of a presence of an uncontrolled source, the SNSA expert is informed by phone and by fax. In the case of a false alarm, no further action is needed.

In addition to routine measurements, a State campaign to identify uncontrolled sources took place from 2004 to 2010. The campaign resulted in around one thousand various non-registered sources in the State. The details of the campaign are provided in Refs [17–19]. The sources were of different origin and very often abandoned after their use. Research, educational, military institutions, factories as well as collections of various items were inspected. The sources were in both forms (i.e. sealed and unsealed) and several hundred kilograms of yellow cake were found. Some of the sources were actually radioactive waste, such as 500 L of radioactive liquids. None of the sealed source found can be defined as high activity sources. Also during the campaign, the oldest source used in Slovenia was identified — a ^{226}Ra medical source used from 1902.

3.2. Analysis of a situation by the SNSA

After the activation of a SNSA inspector, the situation is analysed using all available data, for example results of the measurements, radionuclide identification, physical state of the source, photo of the source and its location. The SNSA experts identify a need to inspect a site or just to give clear instructions to the owner of a source or others involved, as appropriate. The SNSA also acts as a central informational point for all involved (e.g. ARAO, TSOs and user of the source). The judgement to involve appropriate institutions, such as TSOs, is linked to the initial assessment of the SNSA experts.

3.3. Recovery of a control over a source or radioactive waste

If initial assessment requires handling a source or decontamination the SNSA requires following numerous strict rules which are based on the ownership of the source. In general, two cases can be present when source is identified or contamination is present:

(a) Source identified has an owner from abroad because it was found in scrap metal;
(b) Source or radioactive waste has an owner in Slovenia.

In the first case, a source is sent back to the country of origin, taking into account urgent precaution measure, for example the truck with a source is not opened and safety distance when parked is established. In all such cases, the SNSA is urgently informing regulatory authorities of neighbouring States as well as customs and other involved, as appropriate. In a very few cases, if dose rates identified are relatively high and can pose a threat, SNSA inspectors and TSOs are involved in establishing the safety measures for the time the source is in the territory of Slovenia. A typical safety measures are relocation of a source and its shielding at a temporary storage site which is secured.

In the second case, SNSA inspectors visit the site or the owner of the source receives comprehensive instructions from the SNSA experts regarding safety measures including involvement of TSOs or the ARAO. The source is finally placed in the Central Interim Storage for Radioactive Waste operated by the agency which also performs its transport. If appropriate, decontamination procedures take place.

A review of a site of intervention conducted by the TSOs or inspectors, as appropriate, is required if a situation requires procedure which is not routinely performed. In addition, in some cases the involvement of TSOs is routinely required. At the beginning of the establishment of the system, SNSA inspectors regularly visited a site until procedures became routinely used.

Figure 2 shows two photos taken at interventions where according to the situation the inspectors of the SNSA visited a site. On the left is a view on a working area in a hot cell of a research institute where the fire occurred during drying radioactive waste material. On the right is a view on a room in a public garage building where abandoned radioactive material including smoke detectors with a source were abandoned. In both cases, the police were also involved.

As a rule, the owner, if known, pays for the activities on a site of an intervention as well as for laboratory analysis and handling radioactive waste. If this is not the case, the SNSA pays for the expenses of the intervention. In the ten year period, such cases occurred very seldom: approximately only 2% of all interventions were actually paid from the SNSA budget.

At this point of handling an intervention, SNSA inspectors or TSOs can also identify at a site or after laboratory analyses that no safety measures are required — that the SNSA activation was actually triggered by a false alarm.

3.4. Final disposal of a source or radioactive waste

The recovery of a control over source is performed by regulatory authorities of neighbouring States if a vehicle with a source or waste is rejected while entering Slovenia. In all other cases, a source enters into regulatory regime or waste is handled by the ARAO. In all cases, the SNSA follows the transfer of a source or waste either inside or outside the State. The documentation regarding the transfer of a source or waste is carefully handled by the SNSA. In case further

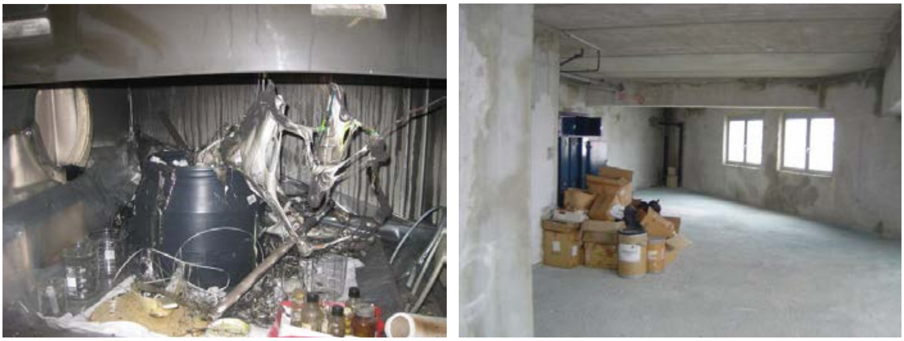

FIG. 2. Typical examples when intervention of SNSA inspectors was necessary due to the complexity of the situation: (left) a view on a hot cell of a research institute where the fire occurred during drying radioactive waste material; (right) abandoned sources and contaminated materials in a public garage building.

inspections are needed at a site of an intervention to upgrade safety measures, an SNSA inspector performs follow-up inspections.

4. EMERGENCY SYSTEM AND THE NATIONAL EMERGENCY PLAN

The emergency system including the SNSA inspection activation is also closely link to the National Emergency Response Plan for Nuclear and Radiological Accidents. An emergency event related to a source can escalate, especially if a high activity source is involved or a large contamination is present. As a result the activation of the State emergency plan is needed. Taking specific scenarios into account sometimes only a part of the State plant can be activated. As a result emergency exercises at the State levels also involve handing radiological events, including terrorist attacks. In 2011, for example, the State emergency exercise was based on a terrorist attack using a ‘dirty bomb’ at a crowded sport arena. A fluent transition from internal SNSA procedures to the State plan is envisaged.

5. DATABASE OF INTERVENTIONS

The SNSA Database of Interventions is based on the available data related to events in Slovenia. The details of the database and the comparison with some other databases given, for example, in Refs [16, 20]:

— IAEA Illicit Trafficking Trafficking Database (ITDB);
— Radioactive Material Transport Event Database (RAMTED), prepared in Germany;
— UK Ionising Radiations Incident Database (IRID).

In the SNSA database, all cases where urgent safety measures related to sources or radioactive waste were required by SNSA inspectors are described. This was the only criteria in order to put an event in the database. When sources or waste are not stored in Slovenia data about the event are usually scarce. Such scarce data are related to physical characteristics of sources or waste as well as to a use of sources or their very first owner.

Radioisotopes involved in the events span from the most radiotoxic given in Group I to the radioisotopes with low radiotoxicity (i.e. in Group V from Ref. [21]). Radioisotopes identified in events include natural radioisotopes in concentrations found in the nature, natural radioisotopes used as radiation sources (e.g. ^{226}Ra), as well numerous manufactured radioisotopes (e.g. ^{241}Am,

^{60}Co, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{67}Ga, ^{85}Kr, ^{90}Sr). Also ^{3}H prepared as a manufactured source was involved in interventions. All possible physical states of sources were present. The events related to sources of ionizing radiation without radioactive materials are very rare.

Stakeholders involved in events can be different institutions, companies or agencies (i.e. research institutions, scrap yards managers, customs, stainless steel factories, communal authority, railway companies, as well as members of the general public). If international transport is involved in an event strong collaboration with regulatory authorities from abroad is necessary. A strong collaboration of all involved is a prerequisite in order to put safety and security measure in place as soon as possible. In cases where criminal activities could be involved, the collaboration with the police is necessary.

The 24 hour on duty service is available by the SNSA expert. As a rule, TSOs make an investigation at a site if necessary in less than a day. The ARAO also respond as appropriate, for example only if temporary safety measures related to the waste are already in place the agency reacts in few days otherwise its reaction is quicker. Generally, the decision to reject a suspicions vehicle entering Slovenia and to share the information with all involved including other regulatory authorities takes only a couple hours.

Figure 3 shows a number of all interventions as a function of time. In recent years, the number of events per year have been quite stable. In a future, this might change taking into account globalization of trade with scrap materials.

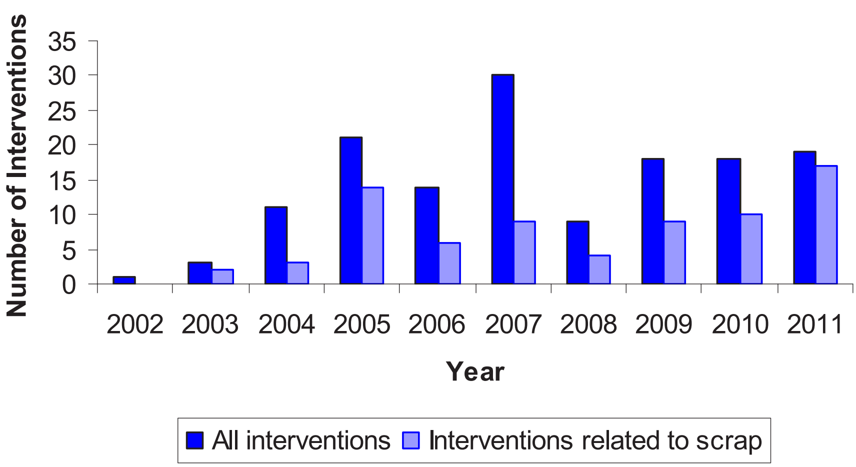

FIG. 3. Number of all events as a function of time and number of events related to scrap as a function of time in the period 2002–2011.

A peak in the number of all interventions in 2007 is related to the SNSA campaign which was conducted by the SNSA inspections in order to find all uncontrolled sources in the State. For comparison, a number of interventions related to scrap are also given, showing the importance of the involvement of scrap yard managers. About 50% of all events are related to the scrap. The details of the analysis of the database are given elsewhere [16].

According to the SNSA database, each event is unique, for example an event related to unexpected exposure of a dosimeter is very different than rejection of vehicles at a border crossing. Nevertheless, some of them are typical or show common characteristics. Such cases can be grouped and altogether six typical cases can be identified.

5.1. Case study 1: Rejection of a source entering the State

Users of radiation monitoring equipment check vehicles with suspicious materials at border crossings or inside the State. In some cases, all vehicles are checked in order to identify uncontrolled radioactive materials. When dose rates indicate a presence of such material, the source is sent back to a State of its origin. The regulatory authorities of neighbouring States are informed by the SNSA without delay. If a transport requires specific safety measure, the identification of the source is also performed: for example, the lightning rod with ^{152}Eu/^{154}Eu was identified at the border crossing and specific safety measures were put in place. According to the SNSA database, around 20% of all interventions in the period 2002–2011 were related to a rejection of a vehicle. As a rule, sources in scrap metal are actually radioactive waste. In some cases, such sources or items containing a source still has a value. Figure 4 (left) shows a photo of a source with ^{226}Ra (i.e. so called ‘radium apparatus’) identified at the border crossing with Croatia. The item, with a source of radon in order to contaminate drinking water, was made in Germany before the Second World War.

5.2. Case study 2: Identification of transported source or waste

When a suspicious material with higher dose rates are identified by measurements in the State, the site is immediately secured and identification procedure takes place. The SNSA is informed immediately. The material on a vehicle is unloaded under a supervision of technical experts checking carefully parts of the material in order to find a source causing the high dose rate. Once identified, it is put in the interim storage for radioactive waste or temporarily stored until full identification (e.g. gamma spectrometry) took place. If the material is radioactive waste, it is later placed into the storage. Otherwise, the item is used without any restrictions. Figure 4 (right) also shows a photo from

FIG. 4. A source with ^{226}Ra (i.e. so called 'radium apparatus') identified at the border crossing with Croatia (left) and unloading of scrap from a carriage causing enhanced dose rate in order to find a source or radioactive waste (right).

an investigation procedure of suspicious material causing enhanced dose rate at a contact of the carriage. Material was unloaded at a secured place under a supervision of technical experts.

5.3. Case study 3: Identification of a source or waste transferred from the State

Very seldom, radioactive material from Slovenia has been unintentionally sent abroad, where a presence of a source or radioactive waste was identified. In one such case, a vehicle was sent back under a close collaboration with the SNSA and owner of the material. In Slovenia, unloading was performed under a supervision of a TSO and waste was finally stored by the ARAO in the storage. In only a few cases, the source was not returned to Slovenia but handled by the neighbouring regulatory authority and placed in the appropriate radioactive waste storage.

5.4. Case study 4: Abandoned radioactive source or waste

The abandoned radioactive sources in the State originated from so called past activities. Users of such sources abandoned them when practices using radioactive materials cease. In specific cases, no sufficient knowledge about risk was present. So users were actually handing radioactive material without proper education or information. In some case, the contamination was identified during inspections. Some of them required extensive decontamination procedures. Figure 5 shows two photos of such materials: ^{3}H with an activity of 129 GBq, installed in military equipment abandoned in a storage facility; and radioactive

FIG. 5. Abandoned sources found during the inspections of the SNSA: (left) ^{3}H source with an activity of 129 GBq, installed in military equipment abandoned in a storage facility;(right) radioactive waste with ^{232}Th, including liquids stored in a research and educational laboratory at one of the faculties.

waste with ^{232}Th, including liquids stored in the research and educational laboratory at one of the faculties.

5.5. Case study 5: Events during handling source or waste

Today, cases with incidents during handling of sources or waste are very rare. The present authorization procedures of all practices with ionizing sources routinely require an assessment of all possible risks as well as strict procedures when incidents or accident happen. Procedures are focused on limiting exposure of people as well as on limiting contamination of the environment. As a rule fire, loss of a source, dispersion or spilling are taken into account. A typical case was a spillage of ^{3}H used in military equipment at a workshop. As already mentioned, a fire of a hot cell at an institute was also studied. In all incidents or accidents, TSOs were strongly involved as well as the ARAO.

5.6. Case study 6: False alarms

The activation of the SNSA system is also a subject of false alarms — activation due to a suspicion that safety measures related to sources are not in place and the suspicion is later not confirmed. Sometimes such alarms are initiated by a member of the general public, while sometimes it is done by experts performing measurements. As a rule, all information is carefully studied and additional investigation of the SNSA inspection unit is conducted if appropriate. In some cases, TSOs are also involved. According to the SNSA database, around 30% of all interventions are false alarms. A typical example is the triggering of an event by a railway company measuring enhanced dose rate at the carrier. It was later found out that a strongbox used at post office contained sand with slightly enhanced natural radioactivity in its double walls.

An unavoidable part of the everyday job of the inspectors is regarding the fact that a member of the general public can always trigger an investigation procedure and taking into account that simple measurements at a site can not always confirm or reject a hypothesis that the material is radioactive false alarms. Nevertheless, by taking lessons to be learned into account, the number of false alarms can be reduced.

6. CONCLUSIONS

From 2001, the SNSA has established a system to handle incidents and accidents with various sources of ionizing radiation. Altogether, 144 cases are recorded in a period of ten years from 2002. The analysis of cases or events shows six typical scenarios which require flexible system in order to cope with various risks associated with jeopardizing the safety and security of sources. Involvement of different institutions as well as members of the general public need to be taken into account. The flexibility of a system needs to enable quick reaction on a global trade with materials. Strong collaboration with regulatory authorities from other States can facilitate appropriate handling of emergency events when radioactive waste or sources are involved.

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INTEGRATION OF SAFETY AND SECURITY FOR THE EFFECTIVE CONTROL AND PROTECTION OF RADIOACTIVE SOURCES IN DIFFERENT FACILITIES AND ACTIVITIES

(Session 8)

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RAPPORTEURS' SUMMARY

Session 8: Integration of Safety and Security for the Effective Control and Protection of Radioactive Sources in Different Facilities and Activities

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Safety measures and security measures have in common the aim of protecting human life and health, protecting society and the environment from harmful effects of radiation. Thus a well coordinated (integrated) approach to safety and security is beneficial to the objectives of each. Several documents published by the IAEA espouse the idea of a close coordination and communication between safety and security experts to ensure the proper use of radioactive sources. The integration of safety and security needs to be performed at both the regulatory level and at the operator level to be effective. Further, it was recognized that it is not possible to achieve effective control and protection of radioactive sources if safety and security aspects are addressed independently from each other.

For some facilities which use radioactive sources, the application of effective security measures is especially challenging due to the open nature of the facility (such as medical and university settings). However, several measures support both safety and security, such as:

- ID cards for staff and electronic card readers;
- Access authorization for staff on an individual basis;
- Alarms for all emergency exits and other exits from specific areas.

Further, organizational measures to verify the trustworthiness of personnel and to raise awareness of, and behaviour toward, security and safety procedures were identified as important factors for success. Inclusion of security concepts into the radiation protection policy as well as the training material for radiation protection may also serve to improve the understanding and interface of safety and security. It is beneficial to ensure that all new users of radiation be given both safety and security training and that current staff receive this as refresher training.

Many facilities already practice many safety measures as part of their everyday routine. The current challenge is mainly to incorporate appropriate security measures without negatively impacting those safety practices. When taking decisions on installing security improvements, safety professionals should be consulted and the measures should ensure a balance (ensuring security while enabling them to be used safely by authorized personnel) and a graded approach (more measures and greater interface for more dangerous materials). The regulatory body also has a responsibility to minimize the regulatory burden from similar, duplicative requirements and to recognize existing safety systems which also support security.

Interaction between safety and security professionals, while necessary in the current age, can be challenging due to different terminology and constraints. Further, appropriate response planning requires coordination and response planning; not just within a facility but also between the licensee and local law enforcement or emergency response agencies, the regulatory body and possibly others.

Often, there are three distinct phases in which safety and security interact for a licensed operator: at the facility (in storage), during transportation and during licensed operations or use. Each of these three phases requires a unique evaluation of the interaction of safety and security to ensure the most balanced and effective result.

States should not consider themselves to be secluded in these efforts to improve security or to ensure a balance between safety and security. Many States are experiencing similar challenges or have identified possible solutions, which may be adaptable. One such collaborative effort involves the governments of Australia, Malaysia and the United States of America. The goal of this collaboration was to establish a holistic gap analysis in regulatory control to include comprehensive elements of security. Efforts also included installing direct communication to the nearest police station and their involvement in mock security drills to prevent or mitigate potentially severe consequences from malicious uses of radioactive sources by an adversary.

Safety and security culture should be integrated and constantly emphasized to staff and management. Occasional refresher and motivational activities may be held to ensure that staff members understand the importance of safety and security culture and practice it regularly. This needs to be done by the operator, but the regulatory body also plays a key role to educate, inform and convince the applicants/licensees.

Beyond integrating safety and security at the operator level, the regulator also needs to integrate security requirements into the existing safety regulations. This includes regulations and procedures for licensing, inspection and enforcement. Due to information sensitivity and separate skill sets, the safety and security aspects of licensing may be handled separately by the regulatory body; however, the final products should be merged to form a single assessment or product. Similarly, a regulator may use separate experts for inspections if staff do not possess sufficient knowledge in both areas.

Establishing requirements for balancing safety and security is not sufficient. A mechanism to validate the operational effectiveness of both the safety and security systems, and their interaction with one another, is also important. This can be used to demonstrate license compliance but also to ensure the systems function as required and as expected. Ensuring proper standard operating procedures are in place and followed helps to build a safety and a security culture while the proper maintaining of records provides opportunity for further review and improvement.

One issue that arose during discussion was the separation of safety and security guidance from the IAEA. While it was agreed that merging safety and security guidance for specific topics or applications makes sense, it is not a decision for the Secretariat. Rather, the different Member State Committee's which oversee publications need to consider this idea.

There is currently no clear definition of safety and security integration or relevant requirements in the various IAEA publications series. On the other hand, a set of 'integration principles' in the safety or security series may assist in building safety and security integration both by authorized persons and regulatory bodies. In addition, international practice demonstrates that safety and security are integrated in multiple ways, including:

- A national coordinating body;
- Combining of regulatory requirements, including licensing, inspection and enforcement;
- Facility plans which involve both safety and security for normal operation and response to an event;
- Training and exercises;
- Safety and security culture.

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SECURITY OF RADIOACTIVE SOURCES IN THE UNIVERSITY MEDICAL CENTRE UTRECHT

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Abstract

During the past years, the security of radioactive sources in the University Medical Centre Utrecht was enhanced by taking different security measures. Radiation protection experts and security professionals worked together in making a fit gap analysis of sources, threats and security measures. The analysis showed where and which action was necessary. Several electronic and organizational measures were taken to comply with the new ministerial order for the security of radioactive sources. All security measures are recorded in a security plan that will be part of the radiation protection programme. Awareness and acceptance of possible threats is essential for staff to comply with security regulations. Frequent inspection of compliance is essential to internalize the new security rules. Plans to test the effectiveness of the security measures in place are under development.

1. INTRODUCTION

Radiation protection aims to ensure that ionizing radiation sources are used safely and to provide an appropriate level of protection for people, animals and the environment against the detrimental effects of radiation exposure. The consequences of incidents with radioactive sources can be severe. Most often, they have a long lasting impact on society and those who work with radioactive sources. Attention for the security of radioactive sources, thus minimizing the threat of misuse, used to be aimed at the nuclear industry. There was no legal obligation for hospitals to take specific security measures.

Recently, more attention is given to the security of radioactive sources with the aim to prevent unauthorized access to, and theft or criminal use of, radioactive materials. The Netherlands Government stimulated facilities to enhance their security of chemical, biological, radiological and nuclear (CBRN) agents as a result of the EU CBRN Action Plan [1]. In 2013, new legislation (ministerial order) for the security of radioactive sources became effective in the Netherlands. Licensee holders are now obliged to take measures to prevent theft and misuse of certain attractive sources in their facility. The University Medical Centre Utrecht (UMC Utrecht) participated in a project for research facilities to enhance security and took several measures.

2. UNIVERSITY MEDICAL CENTRE UTRECHT

UMC Utrecht provides top clinical medical care in a teaching hospital for adults and children. The hospital complex (see Fig. 1) comprises four main buildings and several outbuildings located at the east side of the city of Utrecht, in the centre of the Netherlands. On a daily basis, 20 000 persons enter the premises, either as patient, staff or third party worker, student or visitor. Every year, more than 30 000 patients are admitted and over 130 000 patients make a first visit to the hospital. The buildings have multiple entrances and over 100 fire or other exits on ground level. This, in combination with the open character of the facility, makes security a challenging task.

FIG. 1. University Medical Centre Utrecht.

Within the hospitals, Facility Services operate the Security Department. Security guards patrol the premises and monitor the observation cameras placed on specific locations. Staff are encouraged to report dangerous situations, lost property and unwanted persons. Anyone misbehaving can be denied access to the hospital.

Radioactive sources are used for different purposes. Unsealed sources are in use for diagnosis and treatment of patients (nuclear medicine) and research activities. Sealed sources are used in radiotherapy (brachytherapy) and the irradiation of tissues or cells, either for research or sterilization. The use of these ionizing radiation sources is bound to stringent law (Nuclear Energy Act) and regulations (Radiation Protection Decree), and a hospital radiation protection programme is in place.

3. RADIATION PROTECTION PROGRAMME

The primary goal of the radiation protection programme at UMC Utrecht is to create and maintain an appropriate level of protection for patients, personnel, guests and the environment when ionizing radiation sources are used within UMC Utrecht. Any use of radiation sources must take place in compliance with applicable laws, regulations and standards. UMC Utrecht Radiation Protection Regulations contain internal rules and regulations for working safely with ionizing radiation sources, including X ray equipment and linear accelerators.

The Executive Board is the owner of the Nuclear Energy Act license and has final responsibility for radiation protection at UMC Utrecht. The functional responsibility has been mandated to a qualified radiation protection expert, who heads the Radiation Protection Department. This qualified radiation protection expert is responsible for the internal supervision of compliance with all regulations that apply to ionizing radiation sources.

UMC Utrecht Radiation Protection Regulations hold, among others, the radiation protection policy and the resulting internal rules and instructions. The regulations apply to all uses of ionizing radiation and to all persons within the boundaries of UMC Utrecht. The radiation protection policy is based on the following principles:

— Every use of radiation sources must be justified — that is, the benefits must outweigh the harm resulting from the activity.
— The exposure of humans, animals, goods and the environment to radiation is minimized insofar as is reasonably achievable. Deterministic effects are prevented, and stochastic effects are minimized.

- Unnecessary exposures are to be prevented. The probability and possible consequences of incidents and accidents are limited to an acceptable level.
- The possession or use of radiation sources is permitted only after the qualified radiation protection expert has issued an internal permit. Without such a permit, the possession or use of radiation sources is prohibited.
- The development of new uses for radiation sources is encouraged, supervised and supported within the framework of radiation protection insofar as it is in line with the strategy formulated by UMC Utrecht.
- The expertise of the users of radiation sources is sufficient for the activity; medical practitioners comply with the requirements of the Individual Healthcare Professions Act as well as the Nuclear Energy Act.

The radiation protection programme is in line with the accreditation under the standards of the Joint Commission International which UMC Utrecht obtained in July 2013. From 2012, the radiation policy also addresses security as the licensee is responsible for adequate security measures and the supervision on their correct use.

4. SECURITY PROJECT

Between 2008 and 2011, a security project was carried out to enhance security measures surrounding CBRN agents. Security professionals and the qualified radiation protection expert analysed the then current security status of the radioactive sources. The sources and locations to be protected, the processes in which risk of theft or loss was present and the security elements already in place were identified. Appropriate measures were taken, some specifically aimed at the sources themselves, others to enhance overall security within UMC Utrecht.

4.1. Sources, critical processes and threat analysis

For security purposes radioactive sources are divided in three risk levels or categories: high (Category 1), intermediate (Category 2) and low (Category 3), in line with IAEA recommendations [2, 3]. The risk levels take into account the source activity, the attractiveness of the source and the amount of damage to public health and the environment when a source is used maliciously. IAEA Categories 4 and 5 are not subject to the ministerial order on the security of radioactive sources, basic safety standards apply. Most radioactive materials at UMC Utrecht, for instance all unsealed sources, fall into Categories 4 and 5.

High risk sources are those with an A/D value (A: activity; D: dangerous quantity) above 1000 or high activity sealed sources in transportable units (HASS): for instance, blood or tissue irradiators. The D value corresponds to the activity of a source above which it is considered to cause serious deterministic effects [4]. Category 2 sources are those with an A/D between 10 and 1000 or HASS in high dose brachytherapy units. The A/D value for Category 3 sources falls between 1 and 10. Other Category 3 sources are HASS in low or pulse dose rate brachytherapy units. The radioactive sources at UMC Utrecht that fall under the ministerial order are given in Table 1.

TABLE 1. RADIOACTIVE SOURCES UNDER THE MINISTERIAL ORDER

Source category	Sources	Isotope	No. of sources
1	Irradiators	Cs-137	2 (30 and 70 TBq)
2	High dose rate brachytherapy	Ir-192	1 (max. 500 GBq)
3	Pulsed dose rate brachytherapy	Ir-192	2 (max. 120 GBq)

Critical processes were defined as those processes where loss or theft might be feasible and where security measures should be in place. To determine the critical processes, the logistic chain of the sources was analysed. Receiving goods was noted as a highly critical process, whereas the purchase, storage and transport at UMC Utrecht were considered intermediate critical processes. The actual use or disposal was considered a low critical process. Transport to UMC Utrecht fell beyond the scope of the project.

To determine gaps in security a threat analysis was carried out. From a number of possible scenarios the most relevant (i.e. fraud and theft) were explored and necessary security measures defined. A fit gap analysis made clear where improvements had to be made. Basic security was to be improved and several locations lacked security elements such as cameras or card readers — making these locations more interesting for those with malicious intent. The analysis also showed that not all existing security elements were functional. They were either in the wrong place or were used incorrectly. Behaviour of staff in the prevention of theft or loss was identified as an important factor for success.

4.2. Security measures

Security measures are based on four principles: deter, detect, delay and response. With the emergency room of the Security Department visibly placed at the main entrance, electronic surveillance (CCTV) and frequent surveillance rounds by security guards, potential thieves are deterred. Detection of an attempted theft depends primarily on the frequent use of sources and staff presence at or near the site of the sources. When no staff are present or after working hours, electronic detection is necessary to enable adequate response. The ministerial order on the security of radioactive sources requires security measures to realize different delay times for the different risk categories. Delay time is defined as the time between the detection of the attempted theft and the successful removal of the source. For Category 1 sources, delay time needs to be 10 min. For Categories 2 and 3, the delay times are 5 min and 3 min, respectively.

Security measures have to fit the organization and can consist of structural or electronic measures. The correct mix of these measures delivers the optimum security for the facility. Within the project electronic and organizational measures were taken. All security measures in place are recorded in a site security plan that will be included in the radiation protection programme. Annual evaluation of the security plan is foreseen.

Before introducing specific security measures overall security was enhanced by introducing a new ID card for personnel and the replacement of all electronic card readers within the facility. Authorization of staff on an individual basis was introduced. All emergency exits and other exits from specific areas, among which storage rooms, were fitted with door magnets. When used these magnets generate a central alarm in the emergency room on which the Security Department acts. The CCTV software was updated to allow for facial recognition and early response. On specific locations near transport routes and entrances to storage rooms with radioactive materials extra cameras were placed. One storage room was fitted with biometric access control (see Fig. 2). Mobile sources (i.e. the brachytherapy units) were anchored to the wall, while still keeping an eye for patient hospitality.

Organizational measures that were taken include measures to secure the trustworthiness of personnel to minimize chances of fraud or inside jobs. All personnel and third party workers have to hand in a certificate of good conduct. Although this gives only a minor guarantee on the trustworthiness of the employee, it proves to be a deterrent for applicants.

FIG. 2. Biometric access control.

Other organizational measures are aimed at raising awareness among personnel with respect to the attractiveness of the radioactive sources they use in day to day work and the importance of obliging security procedures. The internal rules and instructions at UMC Utrecht Radiation Protection Regulations were revised to hold specific security instructions for the purchase, handling and storing of radioactive sources. Users of sources under the ministerial order are obliged to participate in a security training every two years.

4.3. Awareness and behaviour: Training and education

Discussing the possibility of security threats with users of radioactive sources and other personnel, the overall reaction was negative. Almost everyone found it hard to imagine someone taking advantage of the materials available or, for instance, deliberately changing orders to obtain radioactive materials. The thought of blackmail or fraud into giving information or materials seemed highly inconceivable. This attitude makes the compliance to any rules regarding the secure use of radioactive materials more difficult.

After the introduction of the extra security measures intensive inspection rounds were carried out. On these rounds, it was found that often security measures were bypassed. Doors were kept open, alternative routes were taken to shorten access routes or sidestep card readers. It was also noted that non-authorized personnel was able to enter restricted areas, and there was low social control.

To promote awareness and compliance, an action plan was developed to integrate security with radiation safety. In all training materials and presentations on radiation, protection security was introduced. Special training for security guards was developed to make sure they have a basic understanding of radioactive sources, their locations on the premises, radiation protection and the significance of a quick and adequate response to security breaches. For staff who are subject to the mandatory instruction, an electronic exam was developed. The successful completion of this exam is a condition to maintain authorization to use the sources.

5. FUTURE CHALLENGES

After completion of the security project radioactive sources at UMC Utrecht are protected in line with the ministerial order. However, continuous attention is needed to keep the sources secure and personnel aware of security measures and possible threats. Compliance to the security measures has to be monitored and actions to enhance compliance have to be taken.

Ways to ascertain the trustworthiness of personnel in key positions are under discussion. It might be desirable to screen the professionals in the Radiation Protection Department. Ultimately, they possess an overall knowledge of all radioactive sources and users in the facility. To improve response, contact is being sought with local police so arrangements can be made on how to report security breaches and the information needed for forensic purposes.

In coming years, the effectiveness of the security measures in place will have to be tested. The results of these tests may lead to improvements, either in the measures themselves or in the ways they are carried out. Primarily, testing will consist of table top exercises. The possibilities of red teaming, where an independent group will challenge the security measures, are being explored.

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IAEA-CN-204/206

APPROACH FOR UPGRADING OF SECURITY MEASURES
Experience and way forward

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Abstract

The IAEA Code of Conduct on the Safety and Security of Radioactive Sources requires every Member State to take appropriate measures necessary to ensure that radioactive sources are securely protected during their useful lives and at the end of their useful lives. In Pakistan, radioactive sources of varying categories are used in industry, medicine, research and agriculture for variety of purposes. Majority of sources in Category 1 are used in the hospitals for the treatment of cancer patients, while a few are used in industrial and blood irradiators. The Pakistan Nuclear Regulatory Authority has taken necessary administrative steps for the physical security upgrades of these sources at par with international standards and is looking forward for the implementation of such upgrades at Category 2 and 3 sources.

1. INTRODUCTION

The IAEA Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [1] requires every Member State to take appropriate measures necessary to ensure that radioactive sources are securely protected during their useful lives and at the end of their useful lives. The objectives of the Code of Conduct are to achieve a high level of safety and security of radioactive sources; prevent unauthorized access or damage to, and loss, theft or unauthorized transfer of, radioactive sources, so as to reduce the likelihood of accidental harmful exposure to such sources or the malicious use of such sources to cause harm to individuals, society or the environment; and mitigate or minimize the radiological consequences of any accident or malicious act involving a radioactive source. In order to achieve these objectives, the Code of Conduct recommends States to establish an adequate system of regulatory control of radioactive sources, applicable from the stage of initial production to their final disposal, and a system for the restoration of such control if it has been lost.

In Pakistan, radioactive sources of varying categories are used in industry, medicine, research and agriculture for variety of purposes. Pakistan has expressed its written commitment to the IAEA and is following the norms of the Code of Conduct in its true spirit through the national regulatory body, the Pakistan Nuclear Regulatory Authority (PNRA).

2. REGULATORY CONTROL OF SAFETY AND SECURITY OF RADIOACTIVE SOURCES IN PAKISTAN

Pakistan has in place an effective national legal and regulatory system of control over the management and protection of radioactive sources. The PNRA is the national regulatory body entrusted with the task to control, regulate and supervise all matters related to nuclear safety, radiation protection and physical protection measures in Pakistan. The PNRA is an independent regulatory body whose regulatory functions are effectively independent of the other functions with respect to radioactive sources such as the management of radioactive sources or the promotion of the use of radioactive sources.

The PNRA has a well established legal and regulatory framework to ensure the safe operation of nuclear and other radiation facilities and to protect radiation workers, general public and the environment from the harmful effects of radiation. The PNRA performs its regulatory functions to ensure that the radioactive sources under its jurisdiction are safely managed and securely protected during and at the end of their useful lives.

3. NEED FOR ENHANCEMENT OF SECURITY OF RADIOACTIVE SOURCES

The majority of Category 1 sources are used in the hospitals for the treatment of cancer patients, while a few are used in industrial and blood irradiators. The hospitals using Category 1 radioactive sources can be categorized as those operating in public and private sectors and those being operated by professional organizations in nuclear sector.

Based on the experience feedback from PNRA inspectors, it was realized that the radioactive sources used by hospitals in public and private sector have least security considerations and that there is a need for upgrading the security measures considering the current security threats. Furthermore, these hospitals have very low financial resources to meet this challenge.

In order to address the situation, the PNRA focused on the Management of radioactive sources in Category 1–3, evaluation of vulnerable facilities and supporting the upgradation efforts by the licensees under the national Nuclear Security Action Plan (NSAP) project. Under this task, the security levels of all such facilities were assessed for identification of weaknesses, recommendations for upgradation of the security measures at vulnerable facilities and propagation of the security culture. The assessment and evaluation was carried out in accordance with national regulations [2], IAEA Nuclear Security Series recommendations [3] and implementing guide [4] and IAEA Safety Standard Series publications.

4. IMPLEMENTATION OF SECURITY UPGRADE FOR RADIOACTIVE SOURCES

4.1. Project management process

Under the aegis of the PNRA–IAEA Nuclear Security Cooperation Programme 2005, a project for security upgrades was completed for hospitals in public and private sector in 2009–2010.

A joint team from the PNRA and the IAEA conducted the assessment and evaluation of two hospitals. The PNRA team conducted the detailed assessment of the remaining hospitals. Based on the assesment, the operational requirements were prepared which provide a statement of the overall security need and includes the site conditions, assets to be protected, perceived threat, consequences, success criteria and site specific limitations to be considered while selecting the technical specifications. After the approval of the operational requirements, the technical specifications of the candidate equipment were prepared followed by the preparation of the statement of work as a bidding document based on the gap analysis. Figure 1 shows the detailed project management process followed throughout the project.

The bidding process was completed as per IAEA procurement rules, leading to the award of contract to the successful bidder. In order to ensure the technical quality for the security upgrades, BS EN Standards such as BS EN 50131, 50132 and 50133 were used for the selection, installation and commissioning of the equipment. Furthermore, the PNRA team conducted inspections of the equipments before, during and after installation.

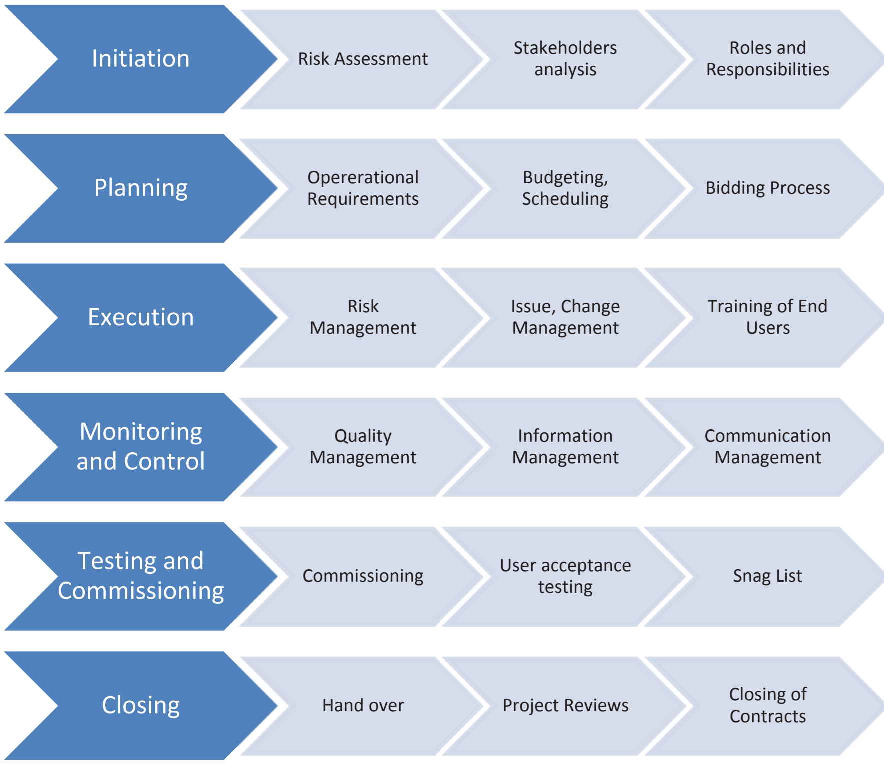

FIG. 1. Project management process.

4.2. Candidate security measures

In order to have a balance between managing sources securely while still enabling them to be used safely by authorized personnel, a continuous coordination was established between the regulatory body, users and other stakeholders. At the same time, it has been ensured that the security measures are applied on a graded basis, taking into account the current evaluation of the threat, the relative attractiveness of the source and the potential consequences resulting from malicious use. As a result, the following is a summary of candidate security measures selected for such upgrades having a combination of deterrence, detection, delay, response and security management:

(a) Detection: Electronic motion sensors were included for immediate detection of any unauthorized access to source locations. In addition, balance magnetic switches (as tamper indicating devices) were included for immediate detection of any attempted unauthorized removal of the sources including by an insider. CCTV systems were also included for the immediate assessment of detection. All the alarms were connected with the control room through alarm panels and monitoring arrangements provided with the help of mimic panels. A general overview of such arrangements is given in Fig. 2.

(b) Delay: Robust doors, mechanical security locks, iron grills were included to provide a balanced system of at least two barriers separating the source and the unauthorized personnel and provision of sufficient delay after detection to enable response personnel to intercede before the adversary can remove the source.

(c) Response: Arrangements were included for monitoring of alarms, timely communication of alarm to the response force members and training of responders on response procedures.

(d) Security management: A combination of PIN pad and mechanical locks were included for the identification and verification of personnel requesting access to secured areas and restricting access to authorized persons only. In addition, provided guidance for the revision of physical security plans of the facilities and procedures for responding to security related scenarios.

(e) Backup power supply systems, sufficient spares and maintenance support for three years were included for sustainability of the upgrade scheme.

(f) Special attention was paid to ensure the balanced protection, protection in depth and quality in the upgrades.

Figure 2 shows a generic sketch of security measures implemented at a hospital.

5. CONCLUSION AND THE WAY FORWARD

The PNRA has been striving hard to establish a sustainable system to ensure that the Code of Conduct is implemented in its true spirit and security measures at the radiation facilities are upgraded consistent with the international standards.

Based on the experience gained during this project, another project for remaining hospitals has been initiated and is in process of implementation. Some of the Category 2 sources particularly the brachytherapy sources used in these hospitals are also covered through such upgrades. It is also realized that the security measures for remaining high activity sources in Categories 2 and 3 should also be upgraded by the users of such sources and the PNRA should continue its support for potential upgrades in future consistent with the IAEA recommendations. All these activities of the PNRA demonstrate the State's commitment to fulfil its international obligations.

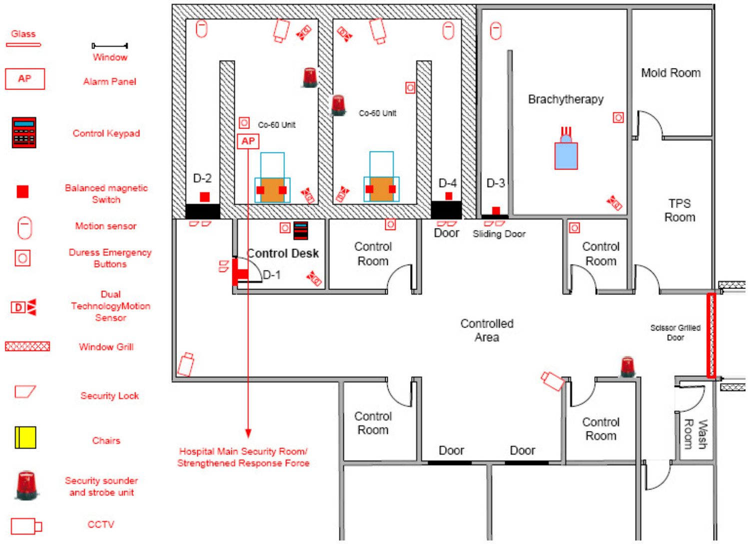

FIG. 2. A sketch of security measures implemented at a hospital.

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SAFETY AND SECURITY INTERFACE
Increasing security of Category 1 and 2 materials within the United States of America

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Abstract

The events of 11 September 2001 heightened concerns about the use of risk significant radioactive materials in a malevolent act within the United States of America. Such an event is of particular concern because of the widespread use of radioactive materials (often contained in sealed sources) in the United States of America by industrial, medical and academic institutions. The theft or diversion of such materials, in risk significant quantities, could lead to their use in a malicious act. A significant culture change occurred at the United States Nuclear Regulatory Commission (NRC) and for the regulated community, to have to consider the potential for malevolent unauthorized access to licensed radioactive materials. This challenge was significant because safety and security professionals spoke ‘different languages’ and have different constraints on their work. Security professionals want to control the flow of information; safety professionals see the need to share information. The paper discusses the safety and security interface and discuss how the NRC ensures the safety and security of Category 1 and 2 radioactive materials in the United States of America.

1. SAFETY AND SECURITY INTERFACE

The United States Nuclear Regulatory Commission (NRC) was created as an independent agency to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The mission of the NRC is to license and regulate the US civilian use of radioactive materials to protect public health and safety, promote the common defence and security, and protect the environment. When radioactive materials were first used in widespread academic, industrial and medical applications, the traditional focus of the NRC safety programme was to control and manage the material from the perspective of preventing inadvertent and unintentional unauthorized access and common theft for monetary reasons. As a result of past incidents involving orphan sources and loss of control events, such as melting sources in smelters, in the late 1990s, the NRC as well as other regulatory organizations outside the United States of America recognized the need to improve the control over risk significant radioactive sources. While it was known that these materials could be used for a malicious intent and the regulatory community was taking responsible actions to address these issues of source control, there was no sense of urgency.

The events of 11 September 2001, in New York City, changed the threat environment and resulted in a significant culture shift regarding the security of radioactive materials. The US framework for security and control of radioactive material requires multi-jurisdictional coordination. Several US governmental agencies have authority, sometimes overlapping, over radioactive materials, and it was agreed that the NRC would domestically ensure security of Category 1 and 2 materials used in commercial, academic and industrial applications within its existing regulatory and oversight structure.

While the NRC's fundamental goals to protect public health and safety, and to protect the environment, remained unchanged, the NRC had to increase its requirements for the secure use and management of radioactive materials. Immediately after 11 September 2001, the NRC worked internally and with other Federal and state agencies to identify priority actions for enhancing the security of risk significant radioactive materials and facilities. These initial actions resulted in the dissemination of a number of security advisories to licensees, which were used to recommend specific actions to enhance security, address potential threats and communicate general threat information. These actions taken by NRC licensees were voluntary and were not legally binding on the regulated community. However, the regulated community understood the change in the threat environment and the need for increased security and implemented the requested actions.

The NRC also looked internally at its organizational structure and, at that time, determined that the assignment of security responsibilities was spread across the agency within various organizational safety programmes. As a result, the NRC established a centralized security office in 2002. This change resulted in streamlined communications, improved the timeliness and consistency of information, and provided a more visible point of contact and effective counterpart to other security focused US Federal agencies. As expected, this centralized security office consisted of staff experienced in physical security programmes and safeguards; however, the NRC also staffed this security office with professionals experienced in radiological safety programmes. Establishing a central security office could have resulted in a separation of safety and security, where the two sides do not effectively communicate with one another. However, the NRC recognized the importance of the safety and security interface and ensured that safety and security professionals worked together within its organization.

With voluntary security measures in place, the NRC proceeded with several different activities in parallel. The NRC provided experts that served on both national and international working groups to determine what radioactive material needed to be protected. With this as its main consideration, NRC staff actively participated in studies, both domestic and international, to look at commonly used medical, academic and industrial radioactive materials (often contained in sealed sources). These efforts eventually became the list of sources found in the IAEA Code of Conduct on the Safety and Security of Radioactive Sources [1].

The NRC also met with Agreement State regulators[1] and the regulated community regarding the voluntary security actions. Due to the sensitive nature of the discussions, these meetings were closed to the public for the most part. The public was kept informed about the occurrence of these discussions, but they were not invited to observe or participate. As an independent regulator, the NRC sought to move away from voluntary security and move towards legally binding requirements which could be subject to inspection and enforcement. As this transition occurred, the safety and security interface was an important consideration. The NRC recognized the need to carefully integrate this increased security with the existing regulatory structure for safety of radioactive material.

At the same time, there was a significant culture change occurring for many licensees, as well as regulators, in that all had to consider the potential for malevolent unauthorized access to licensed radioactive materials. Addressing this culture change has required a cooperative effort by many stakeholders, and a willingness to consider new, and sometimes unfamiliar, approaches to addressing the potential threat. The challenge was significant because safety and security professionals use unique terminology and have different constraints on their work. For example, there was significant debate about requirements to label radiation areas at publicly accessible areas such as hospitals and universities and to label packages of radioactive material. Security professionals recommended removing such labelling; labelling gives the adversary the advantage because of easily locating radioactive material. Safety professionals debated against this because workers, emergency responders and the general public needed to know where such materials were located for safety reasons. It was concluded that ensuring safety and emergency preparedness outweighed the security risk associated with labelling radioactive material.

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[1] The NRC does not solely regulate the safety of radioactive material in the United States of America. In accordance with the law provided certain criteria are met, the NRC can relinquish its authority to regulate the safety of radioactive material to a State. States that enter into an agreement with the NRC to regulate radioactive material are called Agreement States. The NRC does oversee and ensure that Agreement State programmes are compatible and consistent with the NRC's programme.

Together with the law enforcement and intelligence communities, NRC staff conducted threat analyses. These threat analyses documented the credible motivations, intentions and capabilities of potential adversaries. In parallel, the NRC conducted security assessments that evaluated the physical protection system effectiveness of different licensee types in a variety of event scenarios. The NRC developed countermeasures to improve the probabilities that adversaries will be detected, interrupted and successfully neutralized. The NRC conducted facility security assessments, or vulnerability assessments, to help to determine the additional security and control measures need to protect against the risk of sabotage and malevolent use of stolen, risk significant material. Because of the great number and diversity of radioactive material users, the assessments were done on representative facilities.

Once the NRC identified specific actions that licensees needed to take in order to enhance the security and control of risk significant radioactive materials and facilities, the NRC issued Orders which imposed legally binding requirements to individual licensees. It is important to note that it is NRC policy to use a deliberative and transparent process for issuing new regulatory requirements that will impact the regulated community, also known as a rulemaking. Rulemaking is a process that often takes several years to complete. Issuing Orders is another method by which the NRC can issue requirements quickly without considering public or stakeholder comments during the decision making process. However, due to the events of 11 September 2001, it was essential for the NRC to act quickly to remove any security gaps by using Orders, rather than the preferable process by rule.

As a practical matter, the NRC could not issue Orders increasing security across all its programmes at the same time. The NRC took a graded approach to issuing Orders that increased security. Orders for the most risk significant facilities, such as commercial nuclear power plants, were issued in 2002. Large panoramic and underwater irradiators received Orders in June 2003. Manufacturers and distributors of radioactive material received Orders in January 2004. Other risk significant materials licensees received Orders in late 2005. In 2007, the NRC issued the last large set of Orders to licensees, and these orders required fingerprinting and a criminal history background check on anyone with unescorted access to Category 1 and 2 material.

Since issuance of the Orders, the NRC continued inspecting licensees for compliance with security requirements and began the public process to establish security rules in the Federal regulations that will replace the Orders. A significant collaborative effort between the NRC and the Agreement States was necessary to develop a rulemaking that could replace seven sets of Orders and provide generally applicable requirements to a broad set of licensees. There were many insights gained over the years from inspections, self-assessments, and external audits. The challenge was to create a security rule that incorporated realistic approaches to enhancing security that would interface and integrate well with the existing safety rules. The rule is an optimized mix of performance based and prescriptive requirements that provides the framework for the licensee to develop a security programme with measures specifically tailored to its facility. The new security rule was effective from 20 May 2013 and key requirements include:

— Background checks, including fingerprinting, to help to ensure that individuals with unescorted access to radioactive materials are trustworthy and reliable.
— Controlling personnel access to areas where risk significant radioactive materials are stored and used. Access needs to be limited to individuals that require access to the area and are deemed trustworthy and reliable, based on a background and criminal history check.
— Documented security programmes that are designed with defence in depth to detect, assess and respond to actual or attempted unauthorized access events.
— Coordination and response planning between the licensee and local law enforcement agencies for their jurisdiction.
— Coordination and tracking of radioactive materials shipments.
— Security barriers to discourage theft of portable devices that contain risk significant radioactive materials.

As the requirements were developed, the safety and security interface was an important consideration. This increased security had to be incorporated into the existing regulatory structure without causing a degradation of either safety or security by inadvertently implementing conflicting requirements. The NRC also sought to minimize regulatory burden which could be created due to similar, duplicative requirements. Where existing safety systems support security, licensees may take credit for those systems in their security plans. For example, licensees with Category 1 and 2 materials must coordinate with the local law enforcement regarding responses to threats at their facility. The licensee must provide to their law officials a description of its facilities, radioactive materials and security measures. The licensee must also state that it will request a timely armed response by law enforcement to any actual, or attempted, theft, sabotage or diversion. This coordination could include meetings, telephone conferences, plant tours, training in radiation protection table top exercises and other communication to provide information. Certain licensees are required to have an emergency plan in place. Depending on the location within the United States of America, this plan could include routine coordination with local law enforcement to respond to an emergency at the facility. The coordination with law enforcement requirement within the security rule is flexible such that a licensee could use their emergency plan to demonstrate compliance with portions of the security requirements.

2. CONCLUSION

The NRC's fundamental goals to protect public health and safety, and to protect the environment, remained unchanged since the events of 11 September 2001. However, the NRC has increased its requirements for the secure use and management of radioactive materials. This effort required both the regulator and the licensee to view control of sources differently. It was a culture change for both the NRC as a regulator and for our regulated community. Safety professionals, who were more familiar with protecting the public from accident situations, have also to think like a security specialist and to consider that someone could use these sources with intent to cause public harm. NRC Regulations 10 CFR 37, Physical Protection of Category 1 and Category 2 Quantities of Radioactive Material [2], became effective on 20 May 2013. However, the NRC's efforts in security do not end with this rule, the NRC has to continuously assess its programmes to ensure that they protect public health and safety, protect the environment and ensure the secure use and management of radioactive materials.

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IAEA-CN-204/171

SAFETY AND SECURITY IN INDUSTRIAL APPLICATIONS OF RADIOACTIVE SOURCES
Two principles, only one commitment

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Abstract

The Nuclear Regulatory Authority of Argentina applies the basic principles of radiation protection and the necessary requirements to ensure radiation safety and physical security of radioactive sources, established in its Regulatory Standards. The criteria used by Regulatory Standards aim to reinforce and strengthen the measures of safety and security of radioactive material applying the concepts of safety culture and defence in depth. The paper refers to the criteria currently applied to mobile radioactive sources that are used in industrial applications with measurement purposes, studies of well logging and industrial radiography.

1. INTRODUCTION

Since standards AR 7.9.2, Operation of Industrial Radioactive Sources [1], AR 7.9.1, Operation of Industrial Gammagraphy Equipment [2], AR 10.13.2, Standard for Physical Safety of Sealed Sources [3], and AR 10.16.1, Transport of Radioactive Material [4], came into force, more and more deep requirements in order to increase and standardize the measures, procedures and control mechanisms to obtain a high commitment during the use of radioactive material in industrial uses have been implemented.

Regulatory standards applied by the NRA are typically performance standards. However, there are many mandatory requirements to be complied with, but the authorized user of radioactive material can suggest alternatives to the requirements of the applicable regulations, according to the purpose of use of radioactive material and the installation authorized, and should also propose measures in order to ensure radiation safety and security of radioactive sealed sources under their control.

The link between the concepts of safety and security in the use of sealed sources needs to allow the joining of both criteria, developing a set of measures intended to protect people and the environment, as well as sealed sources used for measurement purposes, research or analysis.

2. METHODOLOGY

The different tasks detailed below show some of the objectives set by the NRA for the regulatory control of industrial applications:

(a) Planned inspection programmes to authorized facilities;
(b) Verify the proper compliance with the regulatory framework consisting of standards and regulatory guidelines;
(c) Prepare an inspection and evaluation plan for radiation safety and physical security risk based on radiological, technological and operational complexity, adapted to every type of facility.

In these industrial applications of radioactive material used in mobile devices, different sealed sources and radioactive isotopes are selected according to the type of use or analysis to be performed and can be classified as follows:

— Nuclear gauges (see Fig. 1);
— Cementation and stimulation treatments (hydraulic fracture) in oil applications (see Fig. 2);
— Oil well logging (see Fig. 3);
— Industrial radiography (see Fig. 4).

The use of these devices implies the observation of different requirements regarding radiation safety and security according to the specific uses and processes involved (see Table 1) [1–4].

They include radiation protection measures applied by the authorized facility or installation, safety requirements during transport and operation as well as appropriate physical security measures according to the type of use and activity of the radioisotope used.

Industrial purposes require specific administrative and technical procedures due to the fact that in certain occasions it is be necessary to remove the source from its shielding and to manipulate it during operation. Additionally, the NRA requires the authorized users to implement an emergency programme and to spread them among the staff.

FIG. 1. Mobile nuclear gauge used in surface moisture: density gauge.

FIG. 2. Nuclear gauge used to measure density of cement and hydraulic fracture.

FIG. 3. Shieldings used to transport sealed radioactive sources in well logging applications.

FIG. 4. Shielding used to transport sealed radioactive source in industrial radiography.

TABLE 1. INSPECTION FREQUENCIES OF SEALED SOURCES IN ARGENTINA IN INDUSTRIAL APPLICATIONS

Industrial applications of sealed sources (mobile devices)	Inspection frequency (years)
Nuclear gauges	2.5
Gamma ray scanning	2.5
Well logging	1
Industrial radiography	1

Operators and others potential users (technicians and assistants affected by the procedures) should be properly trained to comply with newly established requirements regarding emergencies.

3. DESCRIPTION OF INDUSTRIAL APPLICATIONS

There are different isotopes used in industrial applications in Argentina (see Table 2).

TABLE 2. RADIOACTIVE MATERIAL USED IN MOBILE INDUSTRIAL APPLICATIONS

Industrial application of sealed sources (mobile devices)	Radioactive isotope	Activity of sources max. (GBq)
Nuclear gauges	Cs-137	0.37
	Am-241/Be	1.48
Gamma ray scanning	Cs-137/Co-60	5.5/18.5
Stimulation or hydraulic fracture	Cs-137	7.4
Well logging	Cs-137	74
	Am-241/Be	666
	Co-60	0.0185
	H-3	55
Industrial radiography	Ir-192	3700
	Se-75	3700
	Co-60	3700

4. RADIATION SAFETY

Authorized users need to implement satisfactory radiation safety programmes according to regulatory standards and the former are examined during the regulatory inspections. Those measures can eventually be optimized by the authorized users by implementing more conservative actions.

All of the criteria taken into account should cover the main elements contributing to radiation safety and should tend, altogether, to diminish incidents and failure rates where different processes, safety devices and operators involved take part [1, 5].

During the regulatory control of radioactive sources, NRA applies international recommendations of the IAEA, such as Guidance on the Import and Export of Radioactive Sources [6] and Code of Conduct on the Safety and Security of Radioactive Sources [7].

4.1. Radiation safety requirements set by NRA standards to authorized facilities

As long as the facilities maintain possession of radioactive material they should comply with regulatory requirements established in the standards so as to reach a high commitment towards radiation safety, as follows:

(a) Radioactive sources should only be used by authorized personnel;
(b) Periodically updated radioactive sources inventory;
(c) Radiological monitoring of radioactive sources;
(d) Calibration of radiation monitors;
(e) Use of specific procedures in case of radiological incidents;
(f) Radiological incidents should be reported;
(g) Storage area of sealed sources should be authorized by the NRA;
(h) Adequate warning signs and labels in the storage and operative areas;
(i) Use of label or tag to identify radioactive source;
(j) Leak test of radioactive sources (required in some applications);
(k) Authorization for import and export of radioactive material in Argentina on a case by case basis;
(l) Apply justification, optimization and dose limits criteria during the use of radioactive sources;
(m) Compulsory disposal of disused radioactive sources;
(n) Authorization for disposal of radioactive material;
(o) Specific training courses for radiological safety officers (RSOs) for each industrial application supervised and approved by NRA;
(p) Obligatory refreshing courses as requirement to renew RSO licence;
(q) Provision of individual dosimetry;
(r) Movement registers of radioactive material (outside the facility or installation);
(s) Direct reading dosimeters (required in some applications);
(t) Dose record received by the RSO and operators;

(u) Demarcating the boundary of the controlled area (required in some applications).

4.2. Radiation safety requirements set by NRA standards to authorized facilities during transport of radioactive sources

When radioactive sealed sources are to be transported, radiological emergencies may arise. Therefore, full compliance with the regulatory requirements established in the regulations applied by the NRA is required — especially regarding proper use of emergency equipment, in case it is needed to handle radiological emergency response [1, 2].

For the transport of radioactive material, Argentina adopted the international IAEA standard in IAEA Safety Standards Series No. TS-R-1, Regulations for the Safe Transport of Radioactive Material [4, 8]. In this context, it also complies with all aspects of radiation safety in transportation [1, 2]:

(a) Check the level of radiation transport packages and points of occupation during transport;
(b) Comply with the dose constraints;
(c) Proper labelling and marking of the packages;
(d) Adequate vehicle placards;
(e) Procedures for radiological emergency situations;
(f) Abnormal events informed effectively to the NRA;
(g) Shipping documents according to standards [4].

It is also convenient to perform the risk assessment during transport in order to avoid radiological consequences:

— Itinerary;
— Increase of traffic during holiday seasons;
— Free animals on the road;
— Adverse weather conditions (e.g. rain, snow and wind);
— Maximum authorized speed according to the type of road.

4.3. Radiation safety requirements set by NRA standards to authorized facilities in location (operation or use)

At this stage, all work prior to operation performed in the worksite, either related to radiation safety issues or to education and training is essential to ensure a high commitment to radiation safety [1, 2]. In order to achieve that objective, the clear interpretation of the risks as well as responsibility and safe handling of radioactive material are highly important [5].

The activities carried out to maintain an adequate level of radiation safety in this task are:

(a) Conduct a safety briefing at the beginning, particularly those aspects related to radiation safety;
(b) Verify that the staff have their individual dosimeter and security features;
(c) Perform the operation of equipment containing radioactive sources correctly and safely;
(d) Apply ALARA (as low as reasonably achievable) concept during operation of radioactive sources;
(e) Check dose rate during operation using a radiation monitor;
(f) Demarcating the boundary of the controlled area (required in some applications);
(g) Restricted access to radiation area;
(h) Conduct a comprehensive review before returning to the facility or installation (e.g. signalling the vehicle and radiation measurements);
(i) Report any news, trouble or deviation detected during the practices.

Additionally, operators and users could provide an adequate spot to handle radioactive sources safely and should take into account group tiredness to take the decision to get back to the facility or installation.

5. SECURITY OF RADIOACTIVE SEALED SOURCES

In addition to what is required in different applicable standards used for radiation protection purposes, the NRA has a specific one that applies to the physical security of sealed sources.

According to the evaluation of risk involving radioactive sealed sources capable of leading to an important radiological consequence in case of theft, unauthorized use and sabotage, among other things, authorized users should take different measures applying the concept of defence in depth.

As well as in every radiation safety aspect, physical protection measures in industrial applications may be gathered into three different groups: security at the facility or installation, transportation and operation.

5.1. Security measures implemented by authorized facilities

During the past decade, several physical protection measures have been implemented to avoid unauthorized use, theft and sabotage, among other things, with the intention of setting protection levels of radioactive material in accordance to the risks and potential consequences posed by the use of radioactive material [1–3]. The following are some examples of security measures applied by authorized users to protect radioactive sources.

(a) Basic analysis on physical security [3].
(b) Storage area of radioactive sources with suitable security measures to avoid unauthorized access:
    - Locks on access or padlocks;
    - Adequate illumination;
    - CCTV;
    - Motion detection;
    - Audible alarms;
    - Perimeter fences;
    - Codified access (magnetic card or digital codes);
    - Access to storage area only by authorized personnel.
(c) Locks on transport packages or containers.
(d) Security staff.
(e) Apply the principle of defence in depth (security culture).
(f) Surveyed parking sites for vehicles that carry radioactive sources permanently mounted (cementation or hydraulic fracture).
(g) Clear instructions during training of security personnel.

5.2. Security measures implemented by authorized facilities during transport of radioactive sources

Authorized users and transport companies need to implement security measures using the principle of defence in depth (i.e. applying elements of delay or deterrence). These measures are the result of a physical security assessment carried out by the authorized user, using mechanisms and systems according to the risk related to the radioactive material used [1]:

(a) Risk assessment during the itinerary from the authorized facility to the location where the task is going to be performed;
(b) Use of communication systems among the different parties involved;
(c) Secure lock of transport packages and fix them to the vehicle;
(d) Mechanisms for monitoring and tracking of vehicles during transport;

(e) Define beforehand the itinerary to be followed;
(f) Evaluate the rest needed before heading back to the facility or installation;
(g) Avoid unauthorized unplanned stops on the way to the operation site and back to the authorized facility or installation.

5.3. Security measures applied by authorized facilities during operations of radioactive sources

Different security procedures are applied during the operation of radioactive sources, as follows:

(a) Place the radioactive sources in an isolated area within the working site, fenced and signalled properly.
(b) Fix the sources using chains and padlocks within the working site.
(c) The keys to radioactive sources locks should only be held by the person responsible for the operation and should not be handled by any other member of the staff.
(d) Radioactive sources need to remain in the containers or shields with their corresponding blocks system.
(e) Surveillance on the radioactive material should be maintained during the whole operation.
(f) When returning to the facility, all the criteria detailed in Section 5.2 will have to be taken into account.

6. DISUSED RADIOACTIVE SOURCES

During the last decade, the NRA proceeded to gradually strengthen the requirement to dispose of every disused radioactive source in the authorized repository [1]. During inspections performed each year by the NRA, inspectors look over the inventory of radioactive sources, and at that time, authorized users are granted a period during which they are required to define the status of each source and dispose of the ones that are not in use at the facility.

The result of this regulatory action was the removal of about 600 radioactive sources declared and registered in RNA between 2002 and 2009.

Likewise, issues linked to this preventive strategy have also been introduced in those training courses recognized by the RNA, required when the RSO has to renew his authorization.

7. CONCLUSIONS

In this description of regulatory requirements contained in NRA standards to control the use of radioactive sources in the industry throughout their useful life, it is necessary to highlight the commitment on the part of the regulatory body towards the enforcement and fulfilment of standards and to maintain high safety and security levels.

Similarly, the commitment of authorized users of the facility staff and all those involved in the operation is essential to define the responsibility of each and every one involved [1–5].

It is also necessary to register procedures, radioactive material protection programmes and criteria to maintain safety and security of radioactive sources.

Accurate instruction and training of RSO, operators and personnel involved in the handling of radioactive material is an essential tool to achieve an adequate level of safety and security in industrial applications.

As the result of the application of NRA standards, high commitment towards safety and security during the use of radioactive sources in industrial applications has been obtained.

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SECURITY OF CATEGORY 1 SOURCES IN MEDICAL FACILITIES THROUGHOUT MALAYSIA

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Abstract

Radioactive substances are commonly used in teletherapy for the treatment of malignant diseases and for blood irradiation. The issue of physical protection of these sources has been a concern due to several incidents relating to radioactive materials originating from medical use. The paper sets out the implementation of physical protection system for Category 1 radioactive sources in medical facilities throughout Malaysia.

1. INTRODUCTION

Radioactive substances are widely used for beneficial purposes throughout the world in industry and in medicine. In medicine, they are commonly used in teletherapy and brachytherapy for the treatment of malignant diseases and for blood irradiation. The issue of physical protection of these sources has been a concern due to several incidents relating to radioactive materials originating from medical use. Probably the best known of these is the Goiânia accident, in which a teletherapy source was dismantled from the machine and ruptured open. This accident was one of the most serious radiological accidents to have occurred to date. It resulted in the death of four persons and the injury by radiation of many others; it also led to the radioactive contamination of parts of the city [1].

It also increases the fear that some radioactive sources are exploited in constructing a radiation dispersal device (or 'dirty bomb') or radiation emission device. Such weapons would disseminate radioactive material over a small area, causing undue harm. The number of victims affected by radiation would be limited including the perpetrators injured due to direct exposure of radiation from the source. There have been several instances of accidental situations that generated dispersal of radioactive material content and to analyse the situation to be presented in cases that terrorist groups infringe on radioactive sources.

Currently in Malaysia, there are only two Category 1 radioactive sources being used in the medical sector — blood irradiators and disused teletherapy sources, conforming to security level A in IAEA Nuclear Security Series No. 11, Security of Radioactive Sources: Implementing Guide [2]. Category 1 sources, if not safely managed or securely protected would be likely to cause permanent injury to a person who handled them, or were otherwise in contact with them, for more than a few minutes. It would probably be fatal to be close to this amount of unshielded material for a period of a few minutes to an hour [3].

This paper sets out the implementation of physical protection system for the Category 1 radioactive sources throughout Malaysia, in line with the goal for Security Level A stated in IAEA Nuclear Security Series No. 11 [2], which is to prevent unauthorized removal of radioactive source, compromising the security of radioactive sources of high activity, as well as public safety and the environment.

2. CURRENT SITUATION

Category 1 sources used for medical purpose in Malaysia comprises blood irradiators and disused teletherapy sources. The activity of these sources ranges from 1400–1700 Ci for blood irradiators and 2000–9000 Ci for teletherapy units. The various sources and their strengths are as listed in Tables 1 and 2.

TABLE 1. LIST OF MEDICAL FACILITIES WITH ^{137}Cs SOURCE FOR BLOOD IRRADIATORS IN MALAYSIA (MARCH 2013)

Hospital/medical centre	Source activity (Ci)
National Blood Centre	1487 and 1447
Ampang Hospital	1557
University Malaya Medical Centre (PPUM)	1620
National University Medical Centre (PPUKM)	1524
Science University Medical Centre (HUSM)	1450
Advanced Medical and Dental Institute (IPPT)	1374

TABLE 2. LIST OF MEDICAL FACILITIES WITH ^{60}Co SOURCE FOR TELETHERAPY UNITS IN MALAYSIA (MARCH 2013)

Hospital/medical centre	Source activity (Ci)
Kuala Lumpur Hospital	2756
Queen Elizabeth II Hospital	8465
Ipoh Specialist Hospital	7295

In August 2008, the Malaysian Atomic Energy Licensing Board (AELB) and the Australian Nuclear Science and Technology Organisation (ANSTO) together with the Global Threat Reduction Initiative (GTRI) established a holistic gap analysis in regulatory control to include comprehensive elements of security under the cooperation of the Program on Nuclear and Radioactive Source Security. One of the elements is the security of medical facilities with Category 1 sources, comprising blood irradiators and teletherapy units which fall under the jurisdiction of the Ministry of Health, Malaysia (MOH). The AELB under the auspices of the Atomic Energy Licensing Act (Act 304, 1984) is responsible for the usage of ionizing radiation in Malaysia. The Director General of Health Malaysia was mandated by the AELB to regulate the safe use of ionizing radiation, solely, for medical purpose.

The GTRI and ANSTO, at the meeting in 2008, suggested to the MOH to have an inspection of the physical protection and security aspects of medical facilities with radioactive sources. The first inspection on medical facilities with blood irradiators was done jointly by the GTRI and the MOH in 2009. The three premises visited were the National Blood Centre, Ampang Hospital and the National University Medical Centre. The National University Medical Centre and the National Blood Centre were among the first facilities to receive the successfully installed and commissioned full physical security features provided by the GTRI. This was then followed by two other blood irradiator facilities, the Science University Medical Centre and Ampang Hospital.

There were three premises with disused teletherapy sources at Kuala Lumpur Hospital, Ipoh Specialist Centre and the Queen Elizabeth II Hospital which were visited by the GTRI. Since the two sources at Kuala Lumpur Hospital and the Ipoh Specialist Centre were in the process of being decommissioned, the GTRI felt that the existing physical security features at these two premises were sufficient. Physical security systems were installed fully in the Queen Elizabeth II Hospital in October 2012.

3. IMPLEMENTATION OF PHYSICAL PROTECTION SYSTEM FOR CATEGORY 1 RADIOACTIVE SOURCES IN MEDICAL

The risk based security options with respect to detection, delay, response functions were taken into consideration for the design of the installed physical security features.

Detection was achieved by visual observation, video surveillance, electronic sensors, accountancy records, seals and other tamper indicating devices, and process monitoring system. Unauthorized access or removal or sabotage of a radioactive source by an adversary can be delayed by using barriers and other physical means (see Figs 1–4). Among the physical security features installed at the premises are:

- — High security metal doors;
- — Balanced magnetic switches;
- — Motion detectors;
- — Fixed and mobile duress buttons;
- — Strobe lights;
- — Area radiation monitors;
- — Electric magnetic locks;
- — Door access systems.

FIG. 1. Exterior of a blood irradiator room.

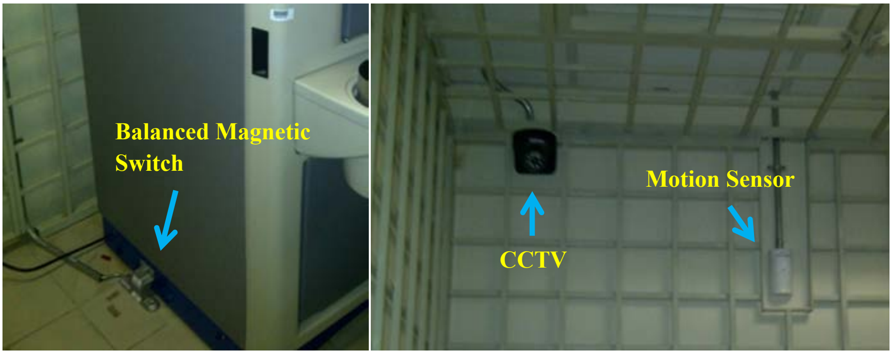

FIG. 2. Detection elements installed in a blood irradiator room.

FIG. 3. Proximity card reader installed for access control.

FIG. 4. Intrusion alarm system and monitoring devices installed at a radiotherapy department.

Response was ensured by having a direct communication line between the first responder and the nearest police station. The police personnel were involved with the mock security drills. This is to prevent or mitigate potentially severe consequences from malicious uses of radioactive sources by an adversary.

In line with one of the basic principles in the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [3], endorsed by the Board of Governors of the IAEA in the year 2003, stating that every “State should ensure that adequate arrangements are in place for the appropriate training of the staff of its regulatory body, its law enforcement agencies and its emergency services organizations”, the first international Physical Protection and Security Management Course on Radioactive Sources for Medical Purpose was conducted in July 2010. This course was well organized by the MOH in collaboration with ANSTO and the GTRI, in compliance with the Program on Nuclear and Radioactive Source Security. The main objective of the training course was to develop a sufficient knowledge of radioactive source security for participants to recognize the need for and the requirements to establish and maintain a national programme for the security of radioactive sources. It was also to ensure that the operators of all the involved facilities were well trained and familiar with the equipment and the security systems provided. Participants were drawn from officials in blood irradiator and radiotherapy facilities based in the MOH and university hospitals. As for the presenters and instructors, national and the international experts from ANSTO and the GTRI delivered the necessary lectures and practical sessions towards enhancing the security of radioactive sources.

Correspondingly, the MOH has already established a system called RADIA, which is an on-line application service which encompasses both government and private sectors. It also serves as the national register of medical radioactive sources, which includes Category 1 and 2 radioactive sources. This is in accordance with another basic principle described in the IAEA Code of Conduct. The information contained in the RADIA system is being secured to ensure the confidentiality of the data is well preserved.

4. INTEGRATION OF SAFETY AND SECURITY

In the MOH, the radiation safety aspect is inherent and well incorporated into the training syllabus of the radiologist, radiographer and medical physicist. All other users of radiation have to undergo compulsory radiation safety training before they are allowed to handle or be in the proximity of medical radiation. A radiation safety committee comprising the director of the hospital together with representatives from the top management, radiology, radiotherapy and nuclear medicine services (where applicable), other users of radiation (e.g. cardiologists, orthopaedic surgeons, vascular surgeons and associated staff) meet periodically to discuss the various issues on radiation safety and security. The radiation protection officer (medical physicist) will ensure that the committee meets regularly and arranges for annual continuous professional courses on radiation safety for all staff involved with radiation in their course of work. The staff will also be sent for relevant courses, so that they will always be abreast with the latest development and technology in their field of work. All new users of radiation will be given radiation safety and security training before they are allowed to handle or use the radiation in their field of work. The safety and security culture is always emphasized and encouraged to each and every staff. Motivational courses are also held to ensure the importance of safety and security are understood by all personnel at premises with radiation usage.

5. CONCLUSION

The challenge is to develop standardized security procedures for these facilities to ensure that arrangements are made for the safe management and secure protection of radioactive sources, particularly Category 1 sources. Healthcare professionals in facilities with high activity radioactive sources will then be provided with clear guidance on how to manage and minimize risks to an acceptable level with different safety and security strategies. This will be for the premises which have different practices and varied security challenges.

The MOH intends to continue working closely with the GTRI and ANSTO to ensure the sustainability of these excellent and comprehensive safety and physical security features for the future.

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INTEGRATION OF SAFETY AND SECURITY FOR EFFECTIVE CONTROL AND PROTECTION OF RADIOACTIVE SOURCES

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Abstract

The paper will present and define the Federal Authority for Nuclear Regulation's (FANR) approach to insert in the current process of controlling radioactive materials, the protection of radioactive sources in the United Arab Emirates against malicious acts. Based on the legislative framework established for the peaceful use of nuclear energy, FANR, as an independent regulatory body, first developed regulations regarding the safe activities involving ionizing radiation other than in nuclear facilities and then proceeded to the issuance of the associated licence. However, the regulation for security of radioactive sources, which is a new issue to be regulated, was established in October 2011 and the licence process, developed and implemented by FANR, has to be adapted to take into account this regulation.

1. THE LEGISLATIVE FRAMEWORK

In April 2008, the UAE Government published the Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy [1], which outlines the government's fundamental principles for its work in the nuclear field. Through the policy paper, the UAE Government endorsed the six principles below that would govern its exploration of a potential civil nuclear energy programme [1]:

(1) The United Arab Emirates is committed to complete operational transparency.
(2) The United Arab Emirates is committed to pursuing the highest standards of non-proliferation.
(3) The United Arab Emirates is committed to the highest standards of safety and security.
(4) The United Arab Emirates will work directly with the IAEA and conform to its standards in evaluating and establishing a peaceful energy programme.

(5) The United Arab Emirates will work in partnership with the governments and firms of responsible nations, as well as with the assistance of appropriate expert organizations.
(6) The United Arab Emirates will approach peaceful domestic nuclear power programme in a manner that best ensures long term sustainability.

The nuclear policy explicitly commits to an approach of conformance with IAEA safety standards.

The Federal Law by Decree No. 6 of 2009 Concerning the Peaceful Uses of Nuclear Energy (Nuclear Law), which applies to the broadly defined nuclear sector, including the management of radioactive sources, was drafted with the requirements of the IAEA safety standards in mind, including the Safety Fundamentals. As its fundamental objective, the Nuclear Law states that "the development and regulation of the Nuclear Sector in the State [United Arab Emirates] will afford priority to safety, Nuclear Safety, Radiation Protection and safeguards". The capitalized terms are defined consistent with the IAEA Safety Glossary [2], thereby linking it to the fundamental safety objective of the IAEA Safety Fundamentals: to protect people and the environment from the harmful effects of ionizing radiation.

The Nuclear Law establishes the Federal Authority for Nuclear Regulation (FANR) as the regulatory body and provides it with legal authority and competence through comprehensive provisions for the making of regulations and guides; licensing after assessment; inspection; and enforcement powers. Further, the Nuclear Law establishes the Board of Management, currently composed of nine UAE nationals, with authority for all regulatory decision making (e.g. licence issuance). FANR has the sole power to make licensing decisions — it is an independent organization, with annual reporting requirements to the Minister for Presidential Affairs, a coordinating Minister. It is also required to apply a graded approach to its regulatory activities.

The United Arab Emirates endeavours to be in compliance with IAEA standards and guidance on nuclear and radiation safety, security and safeguards. In consequence, the United Arab Emirates has implemented regulatory control measures that effectively address the provisions set out in the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) [3] and the associated Guidance on the Import and Export of Radioactive Sources [4]. A review of the implementation of the Code of Conduct was a part of the IAEA Integrated Regulatory Review Service mission to the United Arab Emirates in December 2011.

2. THE REGULATION FOR SAFETY

The Nuclear Law requires that the issuing of licences by FANR is the means of authorization of facilities and activities by the regulatory body. The Nuclear Law explicitly prohibits any person from undertaking regulated activity unless licensed by FANR and prescribes penalties for doing so without a licence. The regulated activities are defined to include use, transport, import/export, storage and disposal of regulated material, in turn defined as radioactive material above the international exemption levels and radiation generators. They are also defined to include the separate stages in the lifetime of a nuclear facility.

Before 2009, the Federal Environmental Agency was regulating the safe use of radioactive material. This responsibility was transferred to FANR after the issuance of the Nuclear Law. Regulation FANR-REG-24, Basic Safety Standards for Facilities and Activities involving Ionizing Radiation other than in Nuclear Facilities, which is based on the IAEA basic safety standards, was issued soon after the creation of FANR. Through FANR-REG-24, FANR defines radioactive material for its regulation as being radioactive material above the activity and activity concentration levels established for exemption in IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS) [5]. The radiation generators that are to be regulated are those used to generate radiation for a purpose. FANR-REG-24 sets out the general grounds for seeking an exemption; and generic exemptions have been granted for certain lighting products and are under consideration for other applications such as smoke detectors using small quantities of ^{241}Am.

Regarding the safety of radioactive sources and radiation generators (regulated material), FANR has been conducting a campaign to license these users, who were formerly regulated under a previous UAE law that divided the regulatory tasks between several competent authorities.

FANR's guidance on the format and content of licence applications included a standard application form and a guide to making an application that expanded on the requirements to submit plans and arrangements for managing safety. FANR licences must specify the facilities and activities covered by the licence and the obligations, restrictions and notification requirements imposed upon the operator. FANR is empowered to amend, renew, suspend or revoke licences. Applicants who are refused a licence or granted a conditional licence may seek a review of that decision.

FANR has already licensed more than 500 entities for the safe use of radioactive material and X ray machine. Each licence authorizes the particular conducts (i.e. possession, use and import/export) for a broadly defined purpose (diagnostic radiology and industrial radiography). The licences are subject to a set of standard conditions and, in a few cases, to special conditions. The duration of currently issued licences is for a period of three years. A standard licence condition requires a request for a permit from FANR for each case for import or export and a prior notice of each transport activity undertaken.

Even while completing its review and assessment of the applications for licensing, FANR has been implementing an active inspection programme for users of regulated material and to date more than 200 inspections have been carried out.

3. THE REGULATION FOR SECURITY OF RADIOACTIVE SOURCES

The Code of Conduct recommends managing the radioactive sources in a safe and secure manner, highlighting the need to do so for at least Category 1 and 2 radioactive sources. The related categorization is detailed and explained in IAEA Safety Standards Series No. RS-G-1.9, Categorization of Radioactive Sources [6]. In order to achieve this objective, each State should establish a regulatory framework for the safety and security of those radioactive materials.

In October 2011, a FANR regulation for the security of radioactive sources was issued. Its scope is to regulate all IAEA Category 1–3 radioactive sources and their aggregation in use, storage and transport. This regulation is based on the IAEA Nuclear Security Series No. 14, Nuclear Security Recommendation on Radioactive Sources and Associated Facilities [7], and its implementing guides: IAEA Nuclear Security Series No. 9, Security in the Transport of Radioactive Material [8], and IAEA Nuclear Security Series No. 11, Security of Radioactive Sources [9]. It provides requirements to protect Category 1–3 aggregation of radioactive sources.

According to regulation FANR-REG-23 for security of radioactive sources, each applicant or licensee using, storing and transporting IAEA Category 1–3 of radioactive sources or aggregation of radioactive sources is to submit a security plan and/or a transport security plan to FANR for approval.

It is required that these plans describe particularly the security system set in place or to be implemented, during use, storage and transportation of radioactive sources, to ensure the three security functions of detection, including assessment, delay and response to a security breach. Each category of source requires security measures commensurate to the risk presented if the radioactive source is used in a malicious act (graded approach).

Requirements are also detailed in order to implement the security management for radioactive sources (e.g. access control, management of keys/badges/cards, inventories and records, training and security awareness) and procedural security measures (e.g. review and revise security plans and security system). All related information is to be protected from unauthorized access, and people intending to grant access to radioactive sources are to have their identity checked and are to undergo a security background check, which includes a security assessment and criminal history checks.

Applicants and licensees are also required to make arrangements with law enforcement personnel with regard to the following:

- Communication following detection of any security breach;
- Notification of security breach;
- Cooperation and assistance to locate and recover source that has been stolen or removed without approval of FANR;
- Annually engagement in practice activities (only for IAEA Category 1 radioactive sources).

Finally, regulation FANR-REG-23 asks for the development of a security culture, to be promoted through the integration of the requested plans in the management system of the licensee and to be explained through the allocation of responsibilities for security to competent and qualified persons.

4. AN INTEGRATED LICENCE PROCESS

FANR has developed and implemented a management system to guide the building of FANR’s organizational model and programmatic activities. The FANR Integrated Management System (IMS) integrates the core regulatory activities with the management and support activities of FANR. All FANR activities that could affect safety, security and safeguards are covered by the IMS. The IMS comprises the IMS Manual, processes (categorized as management, core and support processes) and procedures in a hierarchical fashion.

One of the core management processes defined in the IMS concerns the management of the licensing of regulated activities including uses of regulated material. This licensing process consists of the following main steps:

- Receipt and acceptance of an application;
- Preparation and execution of an assessment (which may include requests for additional information from FANR to the applicant);
- Preparation of a report to formally document the review findings;
- Submission of the report and licensing recommendations by the director general to the FANR Board of Management for decision.

A related licensing procedure for radioactive material and radiation generators was established and implemented following a 3S (safety, security and safeguards) approach. Moreover, the application form as well as the guidance for applying a regulated materials licence were updated on the FANR web site. Finally, the form of the licence was modified to take into account the specificity of the security regulation, including some modifications regarding the conditions of the licence.

Currently, new application and renewal or modifications of licence are reviewed in an integrated manner. However, due to the sensitivity of the information exchanged, the review is done separately by the radiation safety department and the nuclear security department. The two reports of assessment are then collected and provided to the FANR Board of Management for final decision. Finally, one licence taking into account safety and security aspects will be issued.

For a company that had already been licensed from the safety perspective, the process was adapted. The first step was to identify licensees, which are requested to comply with FANR-REG-23. By using the results of the safety processes for licensing and for inspecting, current licensed Category 1–3 radioactive sources and aggregation of were identified. Around 70 licensees were identified as using, storing or transporting Category 1–3 radioactive sources, mainly for non-destructive testing. A few of them are also hospitals operating in particular blood irradiators.

The second step was to organize a visit at each licensed facility with the aims of explaining to the licensee the need to protect radioactive sources against malicious acts, especially the theft and the malicious use of it and then to present the regulation. It was also used to collect information about the status of the security measures already in place.

In the next step, FANR requests the implementation of the regulation, including the submission for approval of a security plan and, if relevant, a transport security plan. Based on the assessment of these provided plans and the eventual request of additional information, the nuclear security department approves the security plan and proposes an amendment of the licence.

After two years of implementation, all identified licensees have provided FANR with the requested security plans. FANR, after requesting additional information, will amend their licence.

Due to the fact that security of radioactive sources is a new issue, FANR had an obligation of constantly educate, inform and convince the applicants/licences in order that they comply with FANR-REG-23. To achieve this aim, for these two years, FANR organized visits and meetings with each applicant or licensee.

Moreover, FANR hosted a workshop in collaboration with the World Institute for Nuclear Security in November 2011 on sharing best practices and enhancing the security of high-activity radioactive sources used in medical, research and industrial applications. The workshop was attended by more than

80 individuals predominantly from the United Arab Emirates, including few others from other Gulf States. Participants represented industrial operations, medical users, security specialists, nuclear regulators and law enforcement. It was the occasion, to share and exchange information with States such as Canada and the United States of America.

Another way for the promotion of security culture and a 3S approach was the annual organization by FANR of seminar with all licensees of regulated materials in the United Arab Emirates. It allows FANR to update the licensees with the last regulatory guides developed and to highlight the holistic approach established by FANR with regard to safety, security and safeguards.

At the present time, FANR is developing its capacity for security inspection as well as the inspection instructions. Due to this fact, the inspection is currently done separately; the annual inspection plan is well coordinated.

5. CONCLUSION

Several years ago, a system of protection and control of radioactive material was established in the United Arab Emirates without taking into account security of radioactive sources requirements. FANR has developed a regulatory framework for the security of radioactive sources and an approach to integrate the associated regulatory requirements in the current process as well as in the inspection process.

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QUALITY ASSURANCE FOR THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES IN PAKISTAN

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Abstract

The paper deals with the safety and security of radioactive sources that are used by different establishments of Pakistan Atomic Energy Commission (PAEC), with emphasis on the quality assurance to make their best use for the benefit of humans and to eliminate the risk of their malicious use to protect people and environment, as per IAEA recommendation. The outcome of this study identifies the strengths and good practices used in PAEC establishments for safety and security of radioactive sources. It also identifies the gaps that exist between present practices and in the codes and guidelines of the IAEA and the Pakistan Nuclear Regulatory Authority.

1. INTRODUCTION

Radioactive sources have been used in everyday life for decades to benefit people. They are used in modern health care to treat cancer patients, as irradiators to preserve food and sterilization of equipment, in agriculture and in many fields of research. Industrial radiography to check welding defects in pipelines and buildings is a common practice. Thermoelectric generation of electricity and sterilization techniques to eliminate disease carrying insects and pests are among many other uses. Regardless of the copious beneficial uses of hundreds of thousands of radioactive sources utilized worldwide, their safety and security is the biggest challenge.

The general issue of the security of radioactive sources is very important where the safety of a source denotes the assemblage of administrative, technical and managerial attributes intended at moderating the chances of people incurring radiation harm as a result of radiation exposure from such a source, while the security of a source refers to attributes aimed at checking any unauthorized custody or actions with the source, by ensuring that control over it is not given up or improperly acquired [1]. Radioactive source may cause harm by both exploding and dispersing its radioactive content or by the opening of the source container releasing the radioactive content into the environment. So the radioactive sources need to be controlled safely and securely. Erroneously used or unsecured radioactive sources can result in death, serious injury and economic loss, as documented from many parts of the world [2–8]. Furthermore, with present scenario of terrorist activity around the world, it is feared that if the radioactive sources are not well protected the terrorist groups can acquire these sources for use with radiological dispersal devices — also known as 'dirty bombs' and consisting of radioactive material combined with conventional explosives. They are aimed at using explosives to scatter the radioactive material over a large area. These explosive weapons may initially kill a few people in the immediate area of the blast but are used primarily to produce psychological rather than physical harm by inducing panic and terror in the target population. Their use would also result in costly cleanup for decontamination. Victims could be irradiated, contaminated with radioactive and chemically toxic materials and injured by the heat and force of explosions [9].

To avoid such harm, IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (BSS) [10] provides an internationally harmonized basis for ensuring the safe and secure use of sources of ionizing radiation and recommends that a quality assurance programme be established that provides, as appropriate, adequate assurance that the specified requirements relating to protection and safety are satisfied.

In order to assure that radioactive sources are managed safely, the execution of suitable management controls is necessary. This system of management controls is known as a quality assurance programme. It can be thought of as a way of managing the safety and security of radioactive sources to ensure that all activities are carried out in a planned, systematic, and controlled way. The IAEA developed a standard on the safety of nuclear power plants dealing with quality assurance, but the general principles can be applied to nuclear facilities other than nuclear power plants.[1] It is usually believed that quality assurance aims to ensure high and continued quality in outcomes of radiation usage. But it must be clearly understood here that the use of radiation is complicated and there is potential for error and uncertainty at every point of the process. Concerns regarding radiation safety and security of radiation sources may occur during each stage of the lifetime of a source, including its distribution, installation, use, maintenance and disposal. But if a quality assurance system is operating well, there is a high degree of confidence that the safety and security of radioactive sources will be observed precisely and that any failures and insufficiencies will be shunned, or at least identified and corrected in time. So the quality assurance needs to be ensured at every step.

Radioisotopes are also used in Pakistan mainly in health care, agriculture, as irradiators to preserve food, in power plants and in research. Pakistan has long been well aware of the need to maintain control over radioactive sources to guard public health and the environment. A regulatory body, the Pakistan Nuclear Regulatory Authority (PNRA), mandated for this task is working effectively in the country monitoring import and export of radioactive sources, security, transportation, safety, emergency preparedness and regulation regarding the safety and security in handling of radioactive sources. Together with the PNRA, the Pakistan Atomic Energy Commission (PAEC), also keeps a strict check on the quality assurance for the safety and security of radioactive sources being used in its establishments. A combined project of the IAEA and the PAEC (Tc-Procurement Order No. PAEC 201203318-BA) on physical protection upgradation is under progress for PAEC Nuclear Medical Centers. In addition to this, the directorate of quality assurance is running a quality awareness programme to enhance skills and knowledge of the personnel of PAEC establishments for effective implementation of quality management system in consonance with the guidelines of the IAEA and the PNRA.[2]

This paper focuses on identifying the strengths and good practices used in PAEC establishments for safety and security of radioactive sources. It is also identifies the gaps that exist between present practices and in the codes and guidelines of the IAEA and the PNRA.

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Code on the Safety of Nuclear Power Plants: Quality Assurance, Safety Series No. 50-C-QA (Rev. 2), IAEA, Vienna (1988).

[2] Ibid. See also Refs [11–14].

2. COLLECTION OF DATA

The data were collected from 28 establishments of the PAEC that use radioactive sources for various purposes, through a questionnaire survey (see end of paper). The survey questionnaire was intended for gap analysis in the standard procedures regarding safety and security of radiation sources in Pakistan. The questions addressed issues pertaining to harmonizing of working procedures with the guidelines of the IAEA and the PNRA. The questionnaire was structured to collect information, focusing on four major areas:

- — Common processes for safety and security of radioactive sources;
- — Acquisition of sources;
- — Safety control;
- — Security control.

3. RESULTS

The data were obtained from 28 establishments of the PAEC that use radioactive sources, both sealed and open. The total number of sources used by these establishments is displayed in Fig. 1, of which 64.28% are health care facilities, 14.28% research institutes and 10.71% power plants. Radioactive sources are also used by higher education facilities (7.14%) and by establishments providing services other than health care (3.57%).

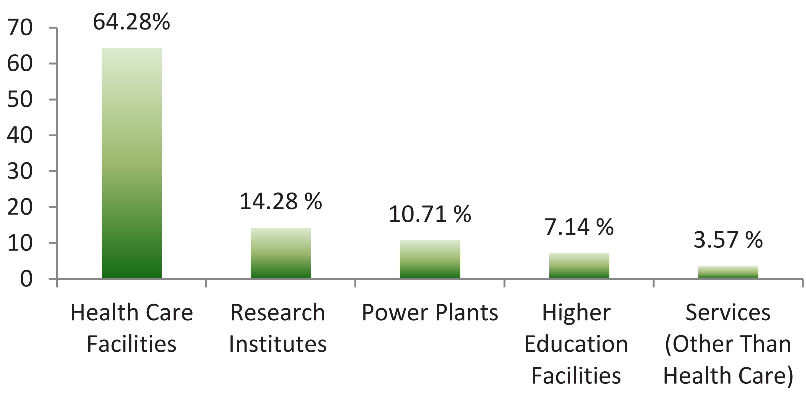

FIG. 1. Relative distribution of radioactive sources used by different PAEC establishments.

The sources are categorized as per IAEA standards and are ranked into five categories according to their relative potential to cause immediate harmful health effects if not safely managed or securely protected [11]. The different categories of sources as per the classification of the IAEA are shown in Table 1. Most of the sources used by these establishments are Category 5 (87%), while Category 3 (0.60%) is the least used of the sources.

TABLE 1. THE DIFFERENT CATEGORIES OF SOURCES USED IN PAEC ESTABLISHMENTS

Establishments	No. of radioactive sources used				
	1	2	3	4	5
I	1	0	0	3	17
II	1	3	0	2	0
III	1	11	0	2	8
IV	0	0	0	1	9
IX	1	0	0	1	0
V	0	0	0	1	4
VI	2	0	4	2	4
VII	1	0	0	2	10
VIII	2	0	0	2	21
X	5	0	2	3	16
XI	2	12	0	2	4
XII	1	0	0	2	34
XIII	2	0	0	2	6
XIV	1	0	0	2	21

TABLE 1. THE DIFFERENT CATEGORIES OF SOURCES USED IN PAEC ESTABLISHMENTS (cont.)

Establishments	No. of radioactive sources used				
	1	2	3	4	5
XIX	1	0	0	2	0
XV	0	0	0	2	5
XVI	1	0	0	0	111
XVII	1	0	0	1	0
XVIII	0	0	0	0	2
XX	3	2	0	0	24
XXI	1	0	0	0	3
XXII	3	0	2	4	356
XXIII	0	0	0	0	60
XXIV	0	0	0	0	111
XXV	70	0	0	0	0
XXVI	0	0	0	0	193
XXVII	0	0	0	0	74
XXVIII	0	0	0	0	59
Total	100	28	8	36	1152

The data for gap analysis in the standard procedures regarding safety and security of radiation sources in Pakistan was considered excluding Category 5 radioactive sources, as they are considered not dangerous.[3] The survey questions

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Code on the Safety of Nuclear Power Plants: Quality Assurance, Safety Series No. 50-C-QA (Rev. 2), IAEA, Vienna (1988).

were structured to address issues pertaining to harmonizing of working procedures with the guidelines of the IAEA and the PNRA [12, 13].The questions were structured to collect information from PAEC establishments using Category 1–4 radioactive sources in four major areas.

3.1. Common processes for safety and security of radioactive sources

The data collected regarding the common processes for safety and security of radioactive sources is shown in Table 2. The data shows that only 25% of the establishments have a policy for safety and security of sources, while almost 62.5% establishments proclaimed to have other procedures regarding safety and security of radioactive sources.

TABLE 2. DATA FOR COMMON PROCESSES FOR SAFETY AND SECURITY OF RADIOACTIVE SOURCES

Processes	Available	Not available
Policy for safety and security of sources	6	18
Control of documents and records	15	9
Non-conformance control	15	9
Internal auditing	15	9
Corrective and preventive actions	15	9
Suggestions/feedback for improvement	15	9
Organization structure	15	9
Competency, evaluation and training of workers	15	9
Calibration programme	15	9
Preventative maintenance programme	15	9

3.2. Acquisition of radioactive sources

The data regarding acquisition of sources show that 43.47% establishments have standard operating procedures (SOPs) for obtaining license from the PNRA for the use of radioactive source in contrast to 56.52% establishments lacking the same. Work instructions for obtaining license from the PNRA for the use of radioactive source, purchase of radioactive sources, inventory of radioactive sources and physical verification of radioactive sources are the weakest areas reflected from collected data as none of the establishments have any. For the purchase of radioactive sources, both by import and from within the countries, only 50% of the establishments have SOPs. Records exist in all the establishments for acquisition of sources. The results are shown in Fig. 2.

3.3. Safety control of radioactive sources

For the quality assurance related to safety control, the collected data reveal that like other aspects, for safety control also 100% of the establishments have records available, while all lack work instructions. It is reflected from data that SOPs exist in 95.83% of establishments for emergency plan for radiation safety of public and workers. The data for safety control is shown in Table 3.

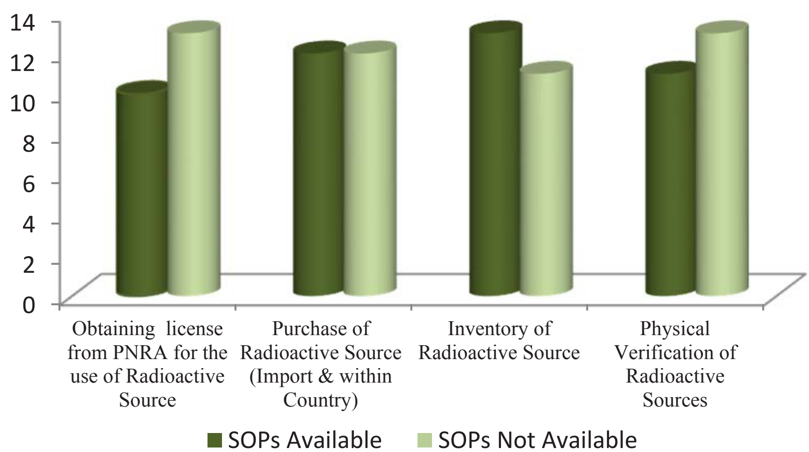

FIG. 2. Data regarding SOPs for acquisition of radioactive sources.

TABLE 3. DATA REGARDING SOPS FOR SAFETY CONTROL OF RADIOACTIVE SOURCES

	SOPs available (%)	SOPs not available (%)
Storage of sources within the establishment regarding the radiation safety of the worker and the general public	79.16	20.83
Routine area monitoring (within and round the source storage)	83.33	16.66
Storage and disposal of disused sources	54.16	45.83
Personnel dosimetry	79.16	20.83
Transportation of radioactive sources within and outside the establishment premises	45.83	54.16
Establishment of a safety committee	100	0
Emergency plan for radiation safety of public and workers	95.83	4.16

3.4. Security control of radioactive sources

The collected data regarding security control of radioactive sources reveal that records are available for all quality assurance processes in the considered establishments. Work instructions are the weakest area and only 37.5% establishments have work instructions regarding authorization for handling and use of radioactive sources. Work instructions for all other attributes including security of stored radioactive sources, security during transfer of sources to the user, security during transportation of sources within and outside the establishment, are lacking. SOPs were available in 100% of organizations for standard security plans, emergency plans for the security of radioactive sources and security measures taken after office hours. Fifty per cent of establishments have SOPs concerning authorization for handling and use of radioactive sources, 62.5 % for security during transportation of sources within and outside the establishment and 75% each for security of stored radioactive sources and security during transfer of sources to the user (see Fig. 3).

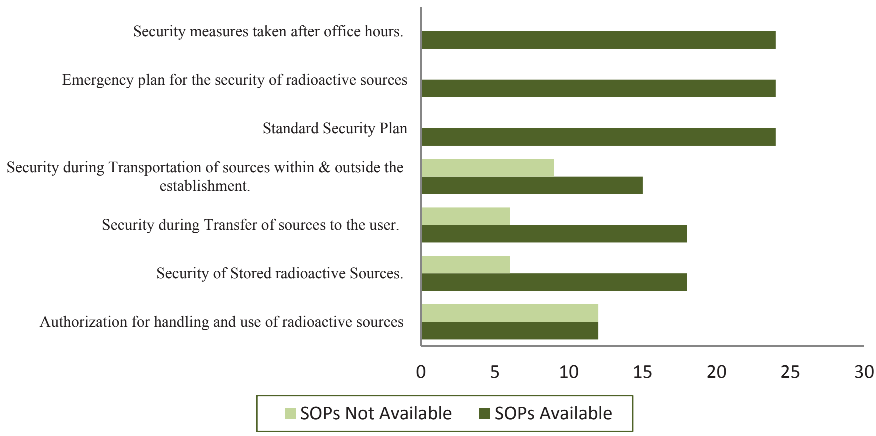

FIG. 3. Data regarding SOPs for security control of radioactive sources.

4. CONCLUSION

Safety and security of radioactive sources is essential and for the safety and security quality assurance system plays a critical role. Realizing the importance of quality assurance in establishments, and more precisely for safety and security of radioactive sources, the higher management of the PAEC has taken important strides in this regard. One of the most imperative initiatives of the PAEC is the establishment of the Directorate of Quality Assurance. The directorate is assisting the establishments using radioactive sources in developing SOPs and work instructions in addition to creating awareness of quality policy. The present study has been done from the platform of this directorate to analyse the gaps existing between present practices and in the codes and guidelines of the IAEA and the PNRA. It reveals that although most of the establishments now have SOPs and records, much effort still has to be done in creating awareness regarding development of work instructions for safety and security of radioactive sources. In addition, to improve the technical know-how for developing and implementing the quality assurance system efficiently and effectively, a more rigorous training programme needs to be designed in addition to the training being imparted into the establishments by the Directorate of Quality Assurance.

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SURVEY QUESTIONNAIRE FOR QUALITY ASSURANCE FOR SAFETY AND SECURITY OF RADIOACTIVE SOURCES

Name of organization:
Contact person name:
Designation:
Email address:
Cell no.:

Please answer by ticking [√] the appropriate answer:

I. COMMON PROCESSES FOR SAFETY AND SECURITY

Processes	Available	Not available
Policy for safety and security of sources		
Control of documents and records		
Non-conformance control		
Internal auditing		
Corrective and preventive actions		
Suggestions/feedback for improvement		
Organization structure		
Competency, evaluation and training of workers		
Calibration programme		
Preventative maintenance programme		

II. ACQUISITION OF RADIOACTIVE SOURCES

	SOPs		WIs		Records	
	Available	Not Available	Available	Not Available	Available	Not Available
Obtaining license from the PNRA for the use of radioactive sources						
Purchase of radioactive sources (import and within country)						
Inventory of radioactive sources						
Physical verification of radioactive sources						

III. SAFETY CONTROL OF RADIOACTIVE SOURCES

	SOPs		WIs		Records	
	Available	Not Available	Available	Not Available	Available	Not Available
SOP for the safety of radioactive sources						
Storage of sources within the establishment regarding the radiation safety of the worker and the general public						
Routing area monitoring (within and round the source storage)						
Storage and disposal of disused sources						
Competency, evaluation and training of workers for handling and use of radioactive sources						
Personal dosimetry						
Establishment of a safety committee						
Emergency plan for the radiation safety of public and workers						

IV. SECURITY CONTROL OF RADIOACTIVE SOURCES

	SOPs		WIs		Records	
	Available	Not Available	Available	Not Available	Available	Not Available
Authorization for handling and use of radioactive sources						
Security of stored radioactive sources						
Security during transfer of sources to the user						
Security during transportation of sources within and outside the establishment						
Standard security plan						
Emergency plan for the security of radioactive sources						
Security measures taken after office hours						

STRATEGIES AND USE OF NEW INFORMATION TECHNOLOGIES FOR COMMUNICATING WITH THE GENERAL PUBLIC ON ISSUES RELATED TO THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

(Session 9)

Chairperson

S.L. ENGSTROM
Sweden

Rapporteurs

R. AL FALAHI
United Arab Emirates

K. KHAIRUL
Indonesia

RAPPORTEURS' SUMMARY

Session 9: Strategies and Use of New Information Technologies for Communicating with the General Public on Issues Related to the Safety and Security of Radioactive Sources

R. Al Falahi, United Arab Emirates
K. Khairul, Indonesia

Traditional methods of sharing information, such as media outlets and direct communication via email are still prevalent, but pale in comparison to the speed with which information is shared over social media. Information travels much faster today than ever before and this is a trend which is not likely to reverse. Technologically savvy and living on-line, today's youth and young adults form an important component for shaping public opinion. Hence, web based and smartphone based applications have become a 'must have' for public or private enterprises.

Informing the public about radioactive sources is no exemption to this. Very few people are aware of the beneficial uses of radiation technologies in medicine, industry and research. Alone the word 'radioactive' scares most people. Interacting with the public using the same novel tools as the rest of the world can help close this information gap.

Effective sharing of information during a nuclear or radiological emergency is critical. However, educating the public on the benefits provided by nuclear and radioactive materials requires that regulators, operators, law enforcement agencies, research institutions and others involved in the safety and security of radioactive sources need to use the vast outreach capability that web based platforms offer. They should inform what sources are good for, what their potential hazards might be and what measures are applied for their safe and secure management. An entity with an active rapport with the public by using such new tools will have the ability to reach out directly to its 'followers' during crisis situations.

One concern with social media involves inaccurate information and counter-information. The Internet has no 'fact checkers', and most organizations have little or no ability to define or restrict what is made available. One challenge is to respond to inaccurate statements with factual ones, clearly and in a timely manner, while not becoming involved in irrelevant debates.

Another critical element of communication involves getting a message out when there is no emergency. This requires involving appropriate stakeholders and engaging them in a dialogue. Such discussions are most important when seeking to establish new facilities or when making a significant shift in policy, related to radioactive material. Sweden offered numerous lessons learned from several decades worth of efforts (some successful and some not so) to establish a spent fuel repository for its nuclear power programme. The presentation outlined the steps, and missteps, which were taken over several decades to shift public opinion from violent opposition to acceptance to an embracing of the opportunity presented.

It is very important to focus a communication project. Contact between individuals and a group is important, and the nuclear industry needs to acknowledge that toxic waste raises anxiety in people. One of the most important things when it comes to communication is to keep communicating until people start joining you.

Information technology plays a crucial role for the establishment an effective dialogue with the general public on issues related to the safety and security of radioactive sources. Informing the general public on issues related to hazards and events helps facilitate the awareness raising process, which helps to protect the population against potential consequences of radioactive exposure. One of the ways to address the problems with radioactive sources, especially with the 'orphan' sources, is to outreach to the population and provide them with the opportunity to contact relevant experts from competent authorities via web resources.

States and regulatory bodies can establish information web sites to help educate the public. But these should be dynamic and help to exchange information rather than remaining stagnant. This is especially true during and after any kind of radiation event. It can also serve as a useful tool for conducting a dialogue between competent experts in the field of safety and security of radioactive sources and the general public.

WHAT HAVE YOU DONE FOR RADIOACTIVE SOURCES ON SOCIAL MEDIA TODAY?

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Abstract

Information travels much faster today than ever. This trend is not likely to reverse. Technologically savvy and living on-line, the Y and Z generations are an important component of shaping the public opinion. Hence, web based applications have become a 'must have' for public or private enterprises. Informing the public about radioactive sources is no exemption to this. Very few people are aware of the beneficial uses of radiation technologies in medicine, industry and research. Alone the word radioactive scares most people. Interacting with the public using the same novel tools as the rest of the world can help close this information gap. Regulators, operators, law enforcement agencies, research institutions and others involved in the safety and security of radioactive sources need to use the vast outreach capability that social media offer. They should inform what sources are good for, what their potential hazards might be and what measures are applied for their safe and secure management. An entity with an active rapport with the public by using such new tools will have the ability to reach out directly to its 'followers' during crisis situations. The paper highlights the power of new information technologies in successful outreach, with examples from the IAEA and others.

1. INTRODUCTION

You could be the best photographer, taking the most amazing images in the most difficult situations, but you will have no audience to admire them if you do not process and show the pictures. We all have to show our work.

Nuclear and radiation related technologies are no different. The vast variety of proven nuclear technologies that are used for the benefit of humankind, such as in medicine, human and animal health, industry and research, are either not known or are feared from. Alone the word radioactive scares most people. Hence, before we try to communicate on risk related issues, we need to understand how people perceive risks. So the simple question is: Why does radiation have a bad name?

Risk communication expert David Ropeik says “choice” is a big factor in how people feel about different kinds of risks [1]: A risk you choose feels less risky than if the very same risk is imposed on you by someone else,” he argues. “The cancer risk from radiation would feel completely different to those willing tanning bed customers if they were tied down and told that they were about to be tanned with radiation released from a nuclear power plant accident.”

Informing the public was not a notion during the early days of this scientific field. The industry has gone a long way since then in opening up, but lack of good understanding of risk perception still prevents successful communication. During my own nuclear communication career, I have heard things that did not serve the purpose [2]:

— I don’t have time now!
— The public won’t understand!
— Journalists always get it wrong!
— They should just read our press release!
— We decide when and with whom we engage!

There are some key facts that these so called communicators have to pay attention to: first, we do not choose our stakeholders. They select themselves as a stakeholder in our work and we do not have the luxury of not engaging with them [3].

2. NEW GENERATIONS, NEW TOOLS

Second, the world population is quite young. A quarter of the world’s 7.2 billion people are under 18 [4] and over half the world population is under 30 [5]. In short, we are surrounded by the dynamic Y and Z generations who have grown up with on-line tools. Those born after 1980 are known as the Y generation — or the WHY generation, as they tend to question everything. The Z generation, those born after 1990, has even a shorter time span of staying focused on traditional outreach methods and is thus known as the ZAPPING generation. They are 24/7 on-line, they do not know a world without the Internet, smart phones or social media applications (apps). Most importantly, they are an important component of shaping the public opinion. Hence, web based applications have become a ‘must have’ for public or private enterprises.

As of October 2013, about 300 social media apps and services were the most frequently used ones among the thousands that are easily available, mostly at no cost for the user [6]:

- — Facebook had 1.2 billion monthly active users (about 700 million active daily).
- — YouTube had over one billion viewers (about 4 billion video views per day).
- — Twitter had more than 500 million users (about 215 million active daily).
- — LinkedIn had about 240 million users.

3. THE IAEA ON SOCIAL MEDIA

This paper builds upon the example of the IAEA in engaging with the public using new on-line tools [7]. Hence, it is not about the issues at hand but about how to communicate.

The IAEA, already maintaining a very sought after web site, has noticed the power of social media applications in time. It launched its YouTube channel in 2007, Flickr galleries in 2008, its Press and Info Blogs in 2008, its Facebook page and Twitter account in 2009, and started sharing information on Slideshare and Scribd in 2010.

However, the Fukushima Daiichi nuclear accident caused by the tsunami that followed the devastating earthquake on 11 March 2011 was a game changer. The traffic volume on the IAEA web site was comparable to a denial of service attack and the pages could not carry the demand. The staff, consultants and interns of the Division of Public Information, which maintains the IAEA's public image were on a 24/7 email management shift. They received more than 1000 emails per week, mostly requesting information or help, some offering technical advice, but often loaded with emotions, anger or anxiety. This was in addition to the similarly large amount of requests coming from journalists.

That the web site could not perform as expected severely hampered the IAEA's ability to inform the public. Hence, a new approach was adopted: use social media to support outreach and reduce the load on the web site. Updates, videos and data were shared on IAEA's social media presence.

Since then, followers of the IAEA's social media channels have increased drastically. Within a month after the disaster, people who 'liked' the IAEA Facebook page grew almost fivefold, while Twitter followers quadrupled. At the time of writing of this paper, the numbers were 12 and 11 times, respectively, of the numbers on 11 March 2011 (see Table 1).

TABLE 1. NUMBER OF IAEA FOLLOWERS ON FACEBOOK AND TWITTER SINCE THE FUKUSHIMA DAIICHI NUCLEAR ACCIDENT ON 11 MARCH 2011

	2011-03-11	2011-03-15	2011-04-11	2013-10-30
Facebook	5 000	10 000	24 000	62 394
Twitter	4 898	9 890	19 151	54 071

The rules of engagement for the IAEA's social media activities were relatively simple:

— Communicate openly;
— Interact quickly;
— Give more emphasis on factual announcements and less on traditional PR messaging or sound bites;
— Tolerate comments, albeit within limits.

The efforts did get attention, not only from the followers but also from mainstream media outlets. At the peak of the Fukushima crisis, the Los Angeles Times informed its readers about the IAEA's YouTube and Facebook presence [8]. A month later, USA Today quoted YouTube spokesperson Annie Baxter as saying [9]: "In Japan, we've had the IAEA take to YouTube to get their messages out. It's going where your audience is. In the week following the earthquake and tsunami, people viewed more than 40 million (disaster-related) items."

4. THINGS THAT HELP, THINGS TO WATCH OUT FOR

Looking back, the IAEA Division of Public Information can reflect on strengths and weaknesses of its social media engagement. On the positive side:

— You can instantly reach massive audiences.
— You get continuous and immediate feedback.
— It empowers your staff to react and adjust approaches.
— It enhances transparency, accessibility, and thus your image.

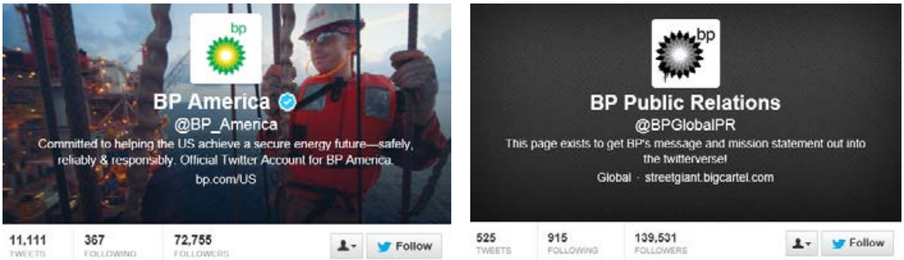

FIG. 1. BP's real Twitter account (left) has half the number of followers as its fake one (right) (30 October 2013).

However, on the downside:

— Your staff resources get stretched to the maximum.
— 'Trouble makers' can hijack conversations.
— The balance between giving quick answers and waiting for official data is a delicate one. Meeting public expectations with institutional realities may prove to be difficult.
— You need to be constantly on the watch against fake accounts on your name. For instance, at the time of writing of this paper on 30 October 2013, a fake Twitter account launched on BP's name after the Deepwater Horizon spill disaster in 2010 had almost double the number of followers (139 000) as the company's real account (72 000) (see Fig. 1).

There are also some operational insights to share from the IAEA's experience:

— Critical comments outnumbered positive comments by three to one.
— Rational, factual, non-argumentative replies worked best.
— There is a strong tendency that users correct each other.
— Continuous monitoring of discussions is absolutely essential.

5. USING SOCIAL MEDIA IN COMMUNICATING ABOUT RADIOACTIVE SOURCES

So how can we use the on-line applications in communicating about the safety and security of radioactive sources? The sheer speed of the Internet would already help us. When a 5.9 earthquake hit near Richmond, Virginia, on

FIG. 2. Reading a tweet about an earthquake before you actually feel it is a revolution in access to information and the speed of its dissemination (courtesy of E. Qualman).

23 August 2011, New York residents read about the quake on Twitter 30 seconds before they actually felt it themselves (see Fig. 2) [10].

Following this example, we cannot help but ask: Had we had Tweets in 1987, would the Goiânia accident in Brazil still have had the same disastrous results? In the world's worst accident involving a radioactive source, would caesium chloride from a dumped source that had ended up in a scrap yard still spread undetected for over two weeks? Could such fast dissemination of vital information save the lives of four people who died of overexposure? Would the 110 000 people still have to be screened? We will never know.

Again, had we effectively used social media in 2011 in Abu Dhabi, would it still take UAE security forces and the Federal Authority for Nuclear Regulation (FANR) 11 days to recover a lost ^{192}Ir source? We will never know.

What we do know is that we still face many challenges in communicating nuclear technologies. In 2007, the IAEA and the International Organization for Standardization launched a new, supplementary radiation warning symbol to help prevent deaths and serious injuries from accidental exposure to large radioactive sources [11].

However, the nuclear community still could not explain this sign to the masses. In 2010, I saw it outside the radiology unit of a major hospital in Abu Dhabi, where I was waiting for my turn for an X ray examination. FANR contacted the hospital immediately to explain the 'supplementary' character of the sign and that it should have been only on top of the shielding housing Category 1–3 sources and not on doors, transportation packages or containers (see Fig. 3). In other words, under normal conditions and unless someone deliberately tries to disassemble the device, members of the public should never see it.

FIG. 3. The supplementary radiation warning sign wrongly placed on a door outside the radiology unit of a major Abu Dhabi hospital, December 2010.

Interacting with the public using the same novel tools as the rest of the world can help close the information gap related to nuclear technologies. Regulators, operators, law enforcement agencies, research institutions and others involved in the safety and security of radioactive sources need to use the vast outreach capability that social media offers. They should inform what such sources are good for, what their potential hazards might be and what measures are applied for their safe and secure management. An entity with an active rapport with the public by using such new tools will have the ability to reach out directly to its ‘followers’ during crisis situations.

6. CONCLUSION: BALANCE BETWEEN OPENNESS AND DISCRETION

Of course, we need to strike the right balance between openness and discretion. There will surely be information that cannot be released due to confidentiality, security or proprietary reasons. However, we must not lose sight of the ultimate goals: protecting people and the environment from “the harmful effects of possible accidents and malicious acts involving radioactive sources", as well as protecting, informing, warning the public of radiation hazards is already enshrined in the Code of Conduct on the Safety and Security of Radioactive Sources [12]. Establishing open communication before crises arise, and enhanced coordination among the regulators, licensees, security forces, first responders and other involved bodies will help in fulfilling this commitment successfully.

To help its Member States improve communication with key groups about safety and security issues related to sealed radioactive sources, the IAEA has developed numerous tools. These range from factsheets and brochures focusing on communicating about sealed sources to scientific publications such as TECDOCs and training materials that include tabletop exercises [13, 14]. The IAEA Incident and Emergency Centre also offers training courses to Member States on the topic.

In the end, as safety and security fall under the national jurisdiction of Member States, it is them who will show and promote openness and transparency, and who will provide timely and objective information to the public. The IAEA and on-line applications discussed above can only help.

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IAEA-CN-204/224

NEW TECHNOLOGIES IN THE COMMUNICATION OF RADIOACTIVE SOURCES
Changes and evolution — the Spanish experience

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Abstract

In Spain, Enresa, the public agency in charge of nuclear waste management, has developed throughout the last ten years a new communication policy based on the knowledge, and in some cases the use, of new technologies. Today, every enterprise must follow their own public image in social networks, but this fact does not include actively participating in these forums. The paper analyses how these new communication tools have improved some technical processes such us large collecting campaigns of radioactive sources. It also analyses the use that Enresa makes of social networks and why it was decided to use them in this way.

1. INTRODUCTION

Enresa is the public agency in charge of nuclear waste management and is also responsible for the dismantling of nuclear power plants. In Spain, nuclear waste is not only produced in the eight nuclear reactors spread across the country, but also in hospitals, industries and research centres. At the moment of managing and disseminating information, Enresa differentiates waste by type and producer.

The main producers of radioactive waste in Spain are nuclear power plants, whose waste management and communication systems are perfectly developed, these are called ‘large producers’. The communication between large producers with society is well defined because the public identify them as producers of radioactive waste.

With other producers, commonly known as ‘small producers’ (hospitals, industries and research centres), the technical management system is also perfectly regulated, but sometimes it is necessary to make a huge communicative effort in order for people to be able to identify those radioactive sources as part of our everyday life.

In Spain, one of the biggest communicative efforts for the collection of radioactive sources was the campaign of radioactive lightning rod headers developed in 1993. As a result of this campaign, 22 000 lightning rod headers were removed. At that time, there were no web sites in daily use, neither was there Facebook nor Twitter. The applications for the collection process arrived by phone or post, and sending a photograph to check if the headers were in fact radioactive took a lot of time. In fact, this was a slow and time consuming way to go about it (see Fig. 1).

Despite the high standards in the operability and efficiency of the control systems implemented in every country, including Spain, there is radioactive waste that for one reason or another remains outside the control system of the authorities.

For this reason, another large campaign related to radioactive source management was the collection of orphan radioactive sources: sources which remained outside the proper authority's controls. The Ministry of Industry and

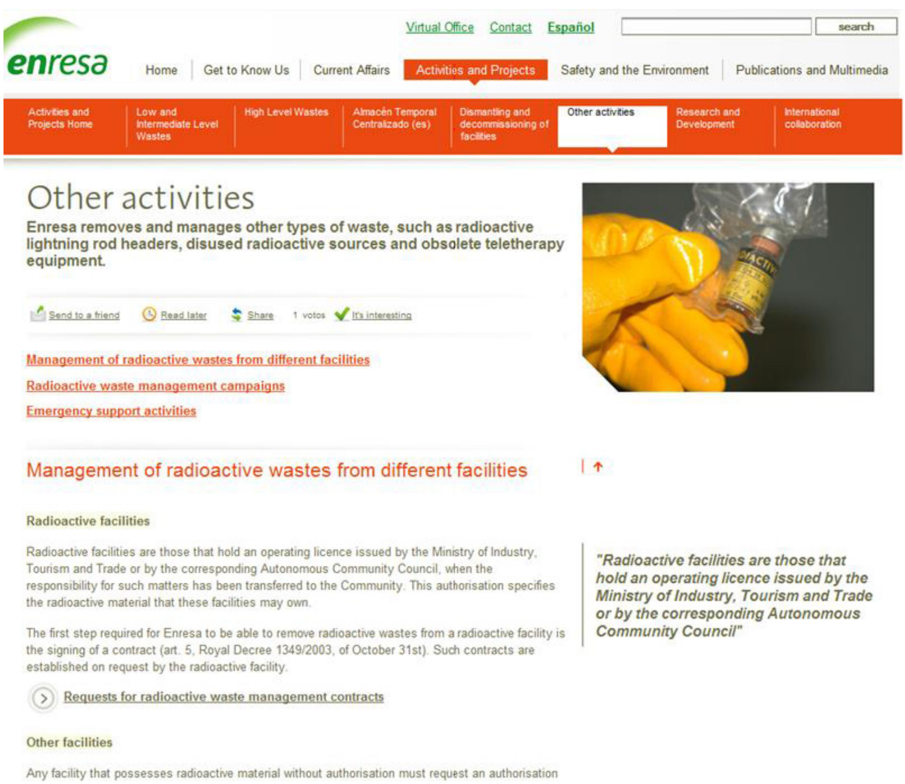

FIG. 1. New organization of radioactive sources management on Enresa's web site.

Enresa launched a campaign in 2007 for the retrieval of orphaned sources. In this case, Enresa used its new 2.0 web site to help people to identify radioactive sources by means of photos and also to improve communication with the general population. Apart from the use of the web site, letters were sent to different institutions, companies, research centres, among others, that due to their history and activity, were able to employ these kinds of sources, or there was reasonable suspicious that they have used them.

In 2007, the Enresa web page contained a highlighted area within the web site which included all of the information necessary to apply for the collection of these kinds of sources. Users were able to find photos, descriptions and relevant data to help identify sources. Also available were application forms and contact information enabling the public to ask for further information and collection assistance (see Fig. 2). As a result, two years later, 461 radioactive sources which were out of the control of the management system were recovered.

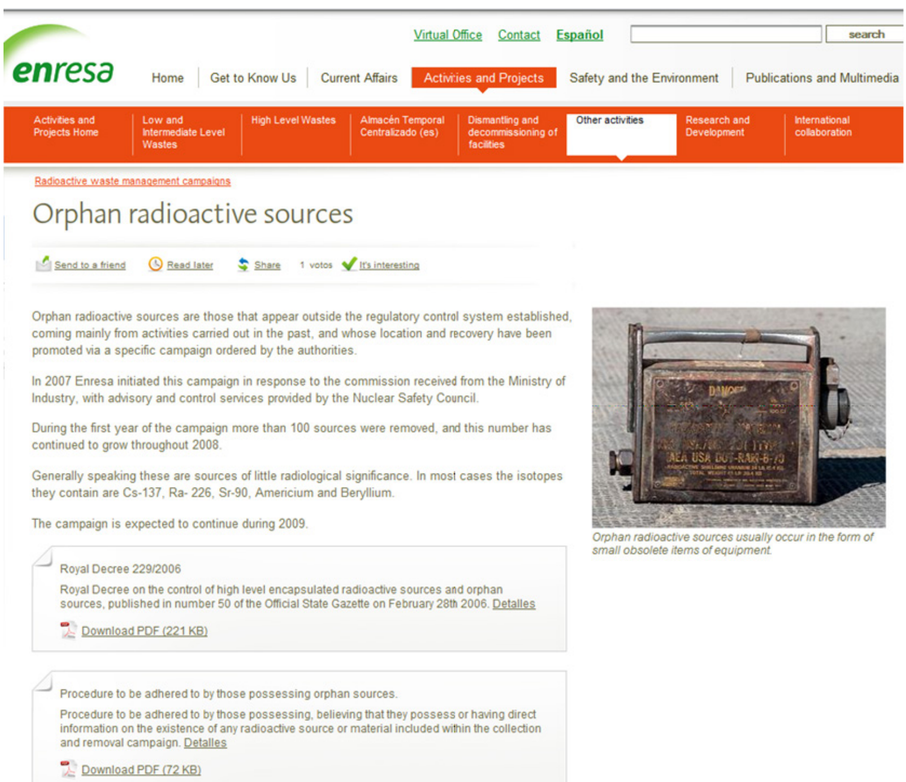

FIG. 2. All the information about orphan radioactive sources on Enresa's web site.

Although the importance of these two campaigns, in which new technologies were to play a significant role in improving communications with the general public, they were just a small part of Enresa's daily activity.

Currently, Enresa has contractual relations with 700–800 nuclear waste producers. These are institutional producers (small producers), whose annual volume is not so high, but they require a very well coordinated management because the sources are different and are situated all around the country. Every two years, Enresa organizes a meeting where people in charge of these 'small' radioactive facilities share their experience and discuss with Enresa's technicians their problems in this area.

Besides the meeting, they also spend one day in the Centralised Low and Intermediate Level Waste Disposal Facility El Cabril in order to understand how these materials are managed by Enresa. From the communication's point of view, this event is very important because it is a good chance to let people know about this part of Enresa's activity, which is very important to the population, but unknown. That is why we organize a press meeting, in which we provide the media with all sorts of information, and invite them to record visually, not only the meeting, but the plant as well. During the final meeting, we also use Twitter to share information and to give people details about the event.

2. TWITTER? YES, BUT TAKE CARE

Enresa has always been discreet in the use of social networks. The company has a profile on Twitter with more than 450 followers and, above all, Enresa uses this media for the wider dissemination of topics or events of interest. Its strategy consists of a combination of a 'not very active' presence with a 'very active' follow-up, always depending on the event and the issue to be addressed.

Follow-up reports are sent out weekly and monthly summing up Enresa's activities in this social network which also involves web participants. This follow-up is divided into topics and sources, amongst other interesting aspects (see Figs 3 and 4).

Enresa took the decision to open a profile in Twitter because of the positioning that it holds with other companies in the sector, ecological organizations and also the main environmental journalists. The idea was to be in touch with these players without being obliged to issue any content in a first stage.

Only one community manager has been designated in Enresa's account, so that all of the messages that are submitted will pass through a filter and go directly to the director of communication. In this way, we are able to better control messages and times. Accordingly, corporate tweets are a part of a well defined strategy, which is only used in specific moments.

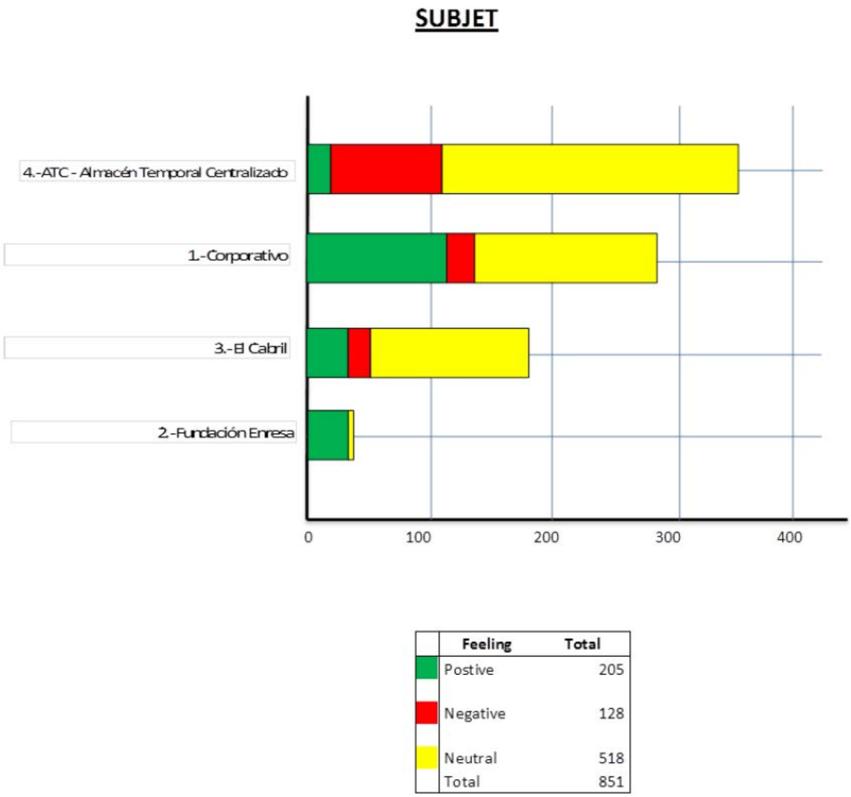

FIG. 3. Image shows corporate tweets, divided in topics, in the first semester of 2011. Some of them are duplicated because more than one topic is referred to.

It would be a mistake to launch communication actions in social networks before monitoring their effects, because the result of this analysis responds to a specific moment and does not offer objective results. In addition, if the monitoring is carried out after a corporate crisis or negative posts on social networks, one could take erroneous decisions, based on specific cases, which are not significant in themselves. The correct action to take would be to perform an exhaustive monitoring before designing a strategy or plan any action. It is also necessary to maintain a regular assessment.

Periodic monitoring is based on a follow-up strategy including press clippings and digital journals that are useful for understanding the interests of the users, the competition and in general the entire nuclear sector in which Enresa moves. Additionally, it is useful to anticipate a crisis of communication or staunch problems of negative press rapidly, before they extend and have an off-line repercussion.

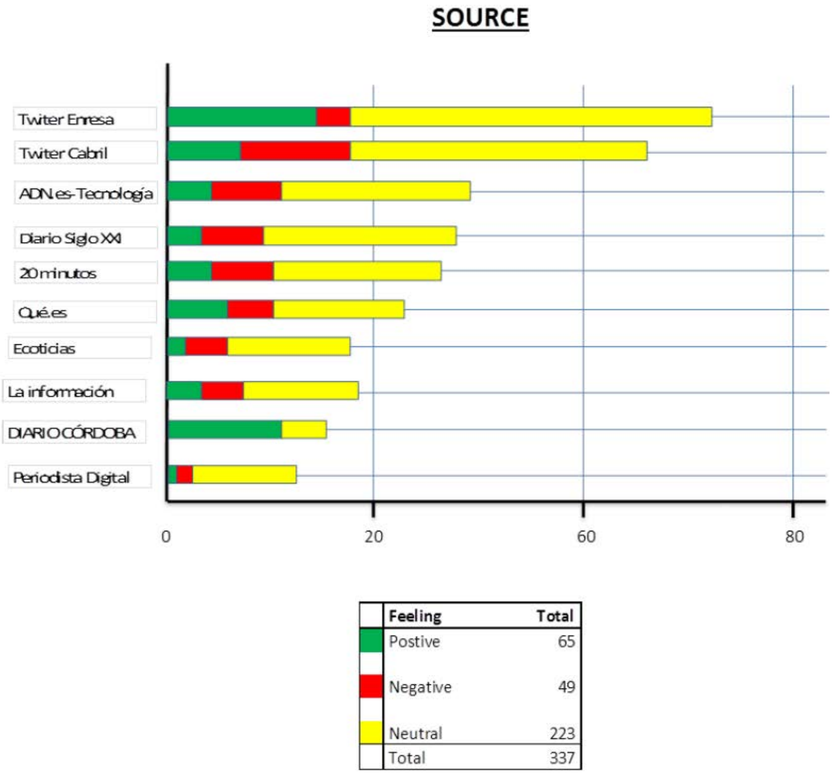

FIG. 4. Main emitters of corporate topics in the first semester of 2011.

For example, through social media we are able to survey the popular opinion, and the effectiveness of a radioactive sources collection campaign. Thanks to monitoring, from a single message like “Enresa has launched a radioactive sources collection campaign”, we can obtain different results, including:

— Positive aspects, such as somebody is making an effort to take all these materials, and that a proper way to manage them exists;
— Negative aspects, such as, “there are out of control radioactive sources”, which can be used by certain groups to do damage to the nuclear sector;
— Neutral aspects, such are those that just inform about the campaign and contribute to extend the message.

Twitter monitoring or follow-ups may be done in a professional way, by using companies which provide a well analysed follow-up, not only quantitatively, but qualitatively as well. By the same token, this monitoring can also be ‘homemade’, using free tools such as TweetDeck, which allow people to perform a constant follow-up, checking at every moment what is said about a corporate topic (see Tables 1–3).

TABLE 1. TWITTER: ENVIRONMENTAL ORGANIZATIONS

Web/group	No. of followers	Classification	Comments
Greenpeace	432 324	Negative	Organization
E. en Acción	45 345	Negative	Organization
WWF	40 042	Negative	Organization
Proyecto EQUO	177	Negative	Organization
Queremosverde	10 544	Neutral	Social web
Reciclame	5 905	Neutral	Social web

TABLE 2. TWITTER: OPINION LEADERS AND ENVIRONMENTAL JOURNALISTS

Web/group	No. of followers	Classification	Comments
EFE verde	36 299	Neutral	Agency
Juan Lopez Uralde	39 797	Negative	EQUO
Ecodez	8 932	Neutral	News
Patricia F. de Luis	10 477	Neutral	Journalist
Clemente Álvarez	8 065	Neutral	Journalist
Fernandez Ordoñez	3 173	Positive	Nuclear physicist
Rafael Mendéz	6 827	Neutral	Journalist
APIA	5 702	Neutral	Journalists’ association

TABLE 2. TWITTER: OPINION LEADERS AND ENVIRONMENTAL JOURNALISTS (cont.)

Web/group	No. of followers	Classification	Comments
Roberto Ruiz	8 553	Neutral	Journalist
M.A. Ruiz	15 950	Neutral	Journalist
Piluca Nuñez	2 046	Positive	Nuclear forum
Javier Riconi	4 108	Negative	Journalist
Pepe Veron	1 994	Neutral	Journalist
Arturo Larena	2 610	Neutral	Journalist
Caty Arevalo	2 958	Neutral	Journalist
Antonio Cerrillo	3 172	Neutral	Journalist
Jose A. Montero		Neutral	Journalist
Benigno Varillas	1 468	Neutral	Journalist
Ismael Muñoz	2 122	Neutral	Journalist

TABLE 3. TWITTER: NUCLEAR SECTOR

Web/group	No. of followers	Classification	Comments
Foro Nuclear	3 782	Positive	Organization
CSN	1 806	Positive	Organization
Enresa	464	Positive	Organization
ACA	14 052	Neutral	Organization
CIEMAT	2 951	Neutral	Organization

From Enresa's Communication Direction, it was decided to use Twitter to disseminate already published information from other company media. For example, Twitter was used by journalists when links were found for certain company information. It was also used to present novelties which appeared, such as the inauguration of a new visitor centre, news about visits or courses and events. However, for the moment, Enresa has decided not to use this tool for technical questions.

3. FACEBOOK AND YOUTUBE

Enresa also has a profile on YouTube with the company corporate videos.

YouTube is the most popular web site for streaming videos. Every day, hundreds of thousands of videos are hung and millions are played by users. This social network is used by a wide range of ages, from 18 to 55, uniformly divided between men and women. YouTube reaches every country in the world. At least 51% of users visit YouTube once a week and 52% of users between 18 and 34 years of age share videos.

Although Enresa's activity in YouTube has dropped, it is among Enresa's objectives to prioritize this social network once we finish our new corporates audiovisual material. We are also studying the possibility of hanging certain technical videos about our work on dismantling nuclear power plants that are usually only shared in our web site (see Fig. 5).

However, Enresa has no Facebook profile, although this social network is always monitored. Enresa decided not to open a Facebook profile due to a certain public that uses information on the network to protest or create polemics instead of information gathering. There are always exceptions, for this reason we have created a student profile in our web aimed at the organization of information in a specific way, wherein users ask questions directly to Enresa, which are answered promptly.

4. ENRESA'S WEB SITE: WHY NOT A CORPORATE BLOG?

Enresa's big bet on new technologies in communication is its web 2.0, a web site designed for communication that focuses on direct communication with the public. The company has opted for its own web log, that it is used to hang current news about the company or its press releases. Also, videos of all company events are posted on the web and the public can make virtual tours and access the contents of our corporate magazines. One section, which encourages users to ask questions, has often served to guide people to the necessary steps

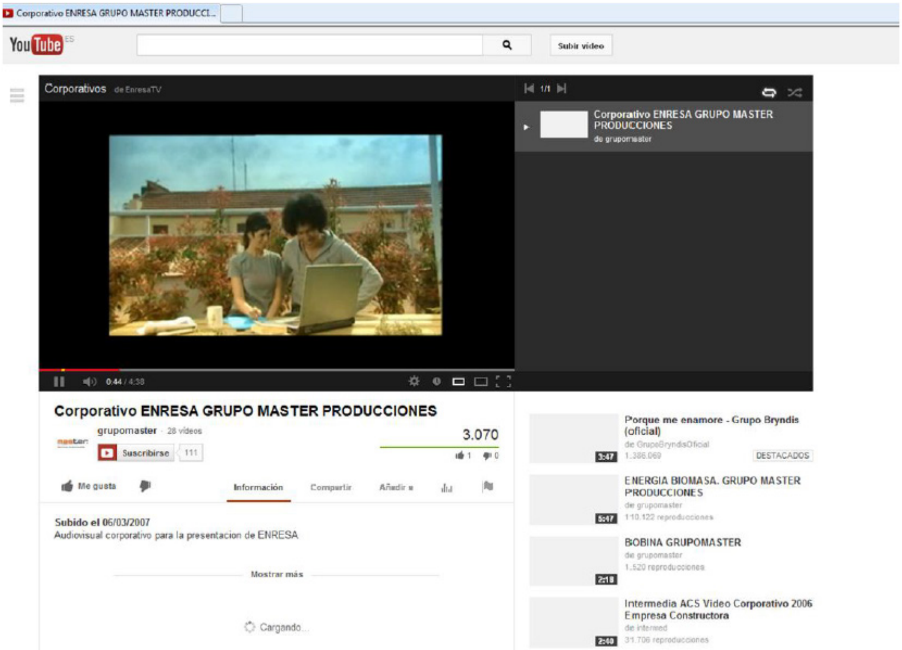

FIG. 5. Home page of Enresa TV on YouTube.

they need to follow in order to develop proper management of a radioactive source. As Enresa does not actively participate in social networks, an effort is made to open a specific channel for allowing the interested public to interact with the company and help them to better understand our mission.

The main reasons that led us to opt for the creation of a corporate blog, which is not yet 100% operational, are:

(a) It is something that the company can develop and maintain on its own, and it does not require specialized knowledge to be implemented.

(b) The cost is minimal, since it can be fed by the company's corporate materials.

(c) This is a key element in the distribution of contents to the major social networks. It is a space where you can expand the contents of the posts and comments of Facebook or Twitter and contextualize YouTube videos. It also serves to effectively increase the dissemination of messages.

(d) Properly managed, a corporate blog can be a powerful tool for on-line corporate reputation, positioning Enresa as an expert on a subject, or a point of reference in its sector.

(e) It will favour the creation of a community of users, hence, facilitating feedback with the readers in a faster and bidirectional way. This is very positive, considering that there is considerable misunderstanding of the activities of the company and its need of positive support.

(f) From a positioning point of view, blogs tend to be better optimized for search engines than many content management systems that are used to create web pages. Enresa's presence on the Internet would be increased with the regular publication of information.

Finally, Enresa emphasizes the importance of the management of radioactive sources in their publications, which are also posted on Twitter. In these publications, the public can find articles and reports which will help them to understand, for example, how to manage a disused radioactive source, or other topics that show the immediacy of our work.

Magazines have traditionally been the main vehicle of communication between the company and the public. Through two publications, of national circulation called Estratos and another area specific magazine, Sierra Albarrana, which is dedicated to the nuclear waste management facility of El Cabril, news and reports of Enresa's daily activities are presented to the public. In these pages, the company also includes informative reports on, for example, how to manage an old radiotherapy unit when its use is no longer viable. Today, the company only has a printed magazine, and when reporting, in depth, on a particular business activity, the material then spreads to other media, either through the web or social networks depending on the subject.

Another important aspect that involves the use of new technologies is that they have changed the way people communicate and even write. Accordingly, the communication department in Enresa has conducted courses such as writing for search engines, so that the information that is posted on our web site reaches as many people as possible.

In social networks, and new communication technologies, ongoing training and constant updating of tools and content is usually necessary. New trends and technologies need to be checked constantly in the same way that messages are monitored. This is to say that nowadays you may think you know everything about the Internet, nevertheless, in a few days everything can change. The advent of electronic mail, led to Facebook, Facebook to Twitter, then WhatsApp and beyond. The proliferation of other more specific social media networks in the future may serve not only to improve the work of communication, but also the development of technical projects.

5. CONCLUSIONS: MAIN FINDINGS

Throughout the last ten years, Enresa has been engaged in the continuous development of new communication strategies based on the advancement of new technologies. According to its experience there are some facts which can be extrapolated to similar situations:

(a) Today, every company needs to know the use of the main social networks (Twitter and Facebook). Knowing their use does not mean to participate actively. It is most convenient going step by step, following a three phase approach:
   (i) Knowing and exploring in depth the tool;
   (ii) Creating a company profile and obtaining followers;
   (iii) At the end, appointing a community manager to disseminate the message of the company on the Internet.

(b) It is very useful to monitor continuously what say social media about the company. Monitoring could be done in a professional way or 'homemade' with free tools on the web.

(c) There are other advances of new technologies like web 2.0 or blogs that open a huge range of opportunities and should be considered when designing a communication strategy.

(d) New social media have already changed the understanding of how the development of technical works in nuclear sector can improve its effectiveness. A good example is a radioactive source collection campaign. In the future, every company will need to be aware of new social networks because they probably will also serve to develop their own technical work.

IAEA-CN-204/229

THE WEB SITE UATOM.ORG AS A PLATFORM FOR COMMUNICATING WITH THE GENERAL PUBLIC ON ISSUES RELATED TO THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

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Abstract

Information technology has a crucial role for the establishment an effective dialogue with the general public on issues related to the safety and security of radioactive sources. Taken note, Ukraine possesses radioactive sources all around its territory. The distribution of the information regarding potential hazards from inappropriate utilization of such sources as well as inadequate actions when such sources are found represents great importance. Informing the general public on these issues would facilitate the awareness raising process, which at the end would help to protect the population against potential consequences of radioactive exposure. One of the ways to address the problems with radioactive sources, especially with the 'orphan' sources, is to outreach to the population and provide them with the opportunity to contact relevant experts from competent authorities via web resources. Such web recourse was created within the joint Ukrainian–Swedish project on information support. The web site, UAtom.org, works as an additional source of reliable information concerning nuclear safety, nuclear security and non-proliferation issues and is a useful tool for conducting constant dialogue between competent experts in the field of safety and security of radioactive sources and the general public to resolve the challenges referenced in the paper.

1. INTRODUCTION

Today, information technologies are implemented in all aspects of our life. With the help of information technology, various tasks in different areas can be resolved in a more efficient manner. Information technology represents significant value for conducting communication activities with the general public on all sorts of issues. One of the main spheres where information technology is of great importance is the communication with the general public issues related to safety and security of radioactive sources. Such technology can assist in the course of establishment mutually beneficial dialogue between authorities and the general public. From one side, the aforementioned authorities can use information technology to provide the population with indispensable information in order to protect their lives. From the other side, the general public, through such technology, can get in touch with relevant experts to obtain competent recommendations on required actions when they find radioactive sources.

Radioactive sources are widely used in Ukraine by more than 600 users. As of December 2012, according to the Ukrainian Registry of sources of ionizing radiation, which records all sources and their movement, there were 12 462 radioactive sources currently in use. Possessing this number of radioactive sources makes this a priority for Ukraine to keep them in a safe and secure way. Despite substantial contributions by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in radioactive sources safety and security regulation, general public involvement is required. Especially it is necessary, with regard to those radioactive sources which are not under regulatory control have never been regulated, were left without attendance, lost, placed in inappropriate location, transferred without proper permission from the State or stolen — namely, ‘orphan’ sources. Furthermore, informational technologies present particular interest in this regard. The problem with orphan sources lies in their potential hazard to public health and difficulties in their detection. Ionizing radiation sources are normally stored in metal containers with thick walls, which, by using the corresponding equipment, make it difficult to identify the presence of a radioactive source inside. Moreover, they could be objects of various sizes and shapes and as a result, they often become items of interest for diverse groups with a variety of purposes. In addition, such sources can be accidently found by the members of the general public and may cause burns, radiation sickness, death, emergence of cancer, tumors, and genetic mutations without proper prevention or treatment. Therefore, this paper will determine the role of information technology for resolving challenges regarding orphan sources.

2. UATOM.ORG

Information technology offers various options to communicate with the general public. To address the issues related to orphan sources, utilizing web resources is the optimum alternative. The full range of tools within web sites can be of great use in informing the population on different aspects of the orphan sources problem, as well as to receive feedback.

In Ukraine, this option was carefully considered. In 2010, a project named State Nuclear Regulatory Inspectorate of Ukraine Information Support was launched. The project developed a web site on nuclear and radiation safety in Ukraine which was implemented with the assistance of the Swedish Radiation Safety Authority (SSM, Strålsäkerhetsmyndigheten). This project was started with an agreement between Cabinet of Ministers of Ukraine and the Government of the Kingdom of Sweden conditioned on technical and financial cooperation and an agreement between SNRIU and SSM on cooperation in nuclear safety and radiation protection.

The main aim of this project is to provide the public with reliable and knowledge based information about nuclear safety, radiation protection and non-proliferation of nuclear weapons through its web site, UAtom.org. The main objectives are the following:

— To be an addition to official regulatory body web site sources of reliable information;
— To be easily accessible and to have clear content;
— To attract the public's attention, including the young population, to the problems the web site addresses;
— To increase the level of awareness within Ukrainian society on the issues of nuclear safety, security and safeguards.

3. UATOM.ORG AND ORPHAN SOURCES

This web resource plays a crucial role in facilitating and implementing required actions to dealing with orphan sources.

In regard to informing the general public on issues related to such sources, a second section was established in 2012 entitled Orphan Radioactive Sources. This section collected general information about ionizing radiation sources (IRS) and comprehensive information on orphan sources.

One of the main areas of this section is dedicated to preventing the orphan sources from emerging. In this section, the general public can obtain information on the State Register of Ionizing Radiation Sources (Register), which is a unified tracing computerized system of registration, accounting and control of radiation sources. The Register files data of all radiation sources in electronic form and traces IRS starting from the moment of their appearance in the territory of Ukraine until their removal or transfer from Ukraine by an enterprise specializing in radioactive waste management. The Register is responsible for searching for information about lost and found IRS and provides an annual report to regulatory bodies. This Register is constantly improving and being enhanced while making a significant contribution to the general public by sharing information about orphan sources. The public, via UAtom.org, is directly connected to competent specialists from relevant authorities which guide them on the necessary steps to overcome potential hazards from IRS. Moreover, up to date information on new cases of radioactive source detection presents an opportunity for the public, especially within the nearest cities, to be aware of new cases and to protect themselves from possible hazards.

It should be noted that interaction with the public through UAtom.org helps experts deliver important messages on the threats from orphan sources and possible catastrophic consequences of selling or misusing radioactive materials.

Illegal possession of radioactive sources increases the threat of use by terrorists. Radioactive materials which can be found in orphan sources may be utilized to construct a radiological dispersal device (RDD). Unfortunately, some members of the public can use radioactive sources without authorization for different purposes, such as selling scrap metals (e.g. containers with radioactive sources inside, among other things) creating an opportunity to conduct business with potential terrorists. In this context the measures to prevent the orphan sources should be a global priority.

It is worth mentioning that UAtom.org, during the international workshop Establishment of Regulatory Control for Abandoned Radioactive Sources and Strengthening of Vulnerable Sources: Experience and Prospects of Ukraine, which was held on 12 December 2012 in Kyiv, was recognized as a tool for fulfilling certain objectives of the US Pilot Amnesty Project within the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction. Our web resource will be utilized as an additional tool to fund the collection and securing of disused or orphaned sources reported by the public. In addition, UAtom.org will be engaged in a public relations campaign to make people aware of the programme and combat the perception that these materials are valuable and can be illicitly sold for profit.

The other part of the Orphan Radioactive Sources section is focused on searching for orphan sources. The general public can find useful information on the web site by using two methods of searching for orphan sources — administrative and physical — which Ukraine is permanently applying.

Information technologies are very important, specifically for applying the administrative method which envisages finding information about orphan sources and conducting relevant surveys that allow authorities to gather necessary information for the establishment of an efficient system for orphan sources detection. Since its establishment, UAtom.org has been used as a technological platform for implementing this method. Despite the existing detection system in Ukraine, UAtom.org is continuing to play a crucial role in conducting necessary surveys and gathering relevant information for public dissemination.

During the 11th Ukrainian Material Protection, Control, and Accounting (MPC&A) Conference, the chief editor of UAtom.org delivered a presentation about the scope of the web resource and an appeal to the participants of the conference for cooperation was made. It is important to involve in detection process, representatives from different authorities who are somehow dealing with orphan sources. It would be useful to mention that after the conference closed, cooperation with the Training Center of the State Border Guard Service of Ukraine was established. This collaboration will contribute to the process of informing the general public on issues related to the different aspects of illicit trafficking of nuclear and radioactive sources. Specific attention, in this regard, would be stressed the fact that according to the Resolution of the Cabinet of Ministers of Ukraine of 2 June 2003 No. 813, "in case of detection of radioactive material in the course of border control, or environmental or radiation monitoring, financial liability for expenses, related to radioactive materials being in illicit trafficking, shall rest with the owner (user) of cargo, while in case of absence of the owner, the responsibility shall be placed upon the local power authorities." In this context, UAtom.org, through its News section, provides the general public with updated information on any changes in relevant legislation. For instance, made available on the web site is information on the status of enacting the Law of Ukraine: On amending Article 265 of the Criminal Code of Ukraine pertaining to voluntary turn-in of radioactive materials. This amendment introduces incentive measures on voluntary turn-in of orphan IRS and radioactive waste by population.

The value of the UAtom.org in focusing attention on, and informing the general public about, the problems with orphan radioactive sources was mentioned in the framework of the IAEA Contact Expert Group (CEG) Workshop: International Programmes for Management of Disused Radioactive Sources in Russia and Countries of Former Soviet Union, which was held 11–12 April 2013 at the IAEA headquarters. The problem of disused powerful radioactive sources has always been in the scope of CEG discussions and in the programmes of its members. Our web resource was acknowledged as a useful platform to exchange information and elaborate on necessary efforts towards disused radioactive sources management with the view of identifying main priorities and presenting recommendations on specific projects for further cooperation.

UAtom.org is also an interactive web resource. The web site enables electronic submission of various questions, requests and comments, among other things. The representatives of our Expert Council provide competent feedback in a timely manner. Particular interest in this option has been expressed by our younger generation. The representatives of the web recourse conduct active dialogue with students, PhD candidates, and young specialists and receive valuable feedback. Recently, the chief editor of UAtom.org presented information about the web site and its value as a useful tool for communicating with the general public on issues related to the safety and security of radioactive sources to 32 young people from Ukraine, the Russian Federation, Moldova, and Georgia during Odessa Non-Proliferation Summer School Global nuclear and missile proliferation and its impact on Ukraine. He supplied participants with clarifications and explanations on exterior views of radioactive sources, especially the orphan sources and their potential risks and what proper actions should be taken when they find such sources. SNRIU inspectors, when lecturing in schools and universities on safety and security issues, promote UAtom.org as a useful and interactive resource.

4. THE FUTURE ROLE OF UATOM.ORG

The web site represents a crucial role for the SNRIU as well as for other involved organizations. We are continually obtaining requests from different stakeholders to post information, available to the general public, on issues related to the safety and security of radioactive sources, especially orphan ones. This resource has State's support and is internationally recognized. In the future further promotion is planned. Within the next few years, UAtom.org will be involved in the national celebration of the 20th anniversary of Ukraine joining the Treaty on the Non-Proliferation of Nuclear Weapons. According to the strategy for the implementation of the main purposes of this project, UAtom.org was recognized as the platform to inform the general public about various aspects of non-proliferation, especially on the nuclear security side, about the threats of nuclear terrorism existing because of the possession nuclear material and radioactive sources by terrorists or other criminals. Moreover, it plans to make the web site more interactive in order to involve additional public groups and to create a more efficient dialogue with the general public. Additionally, we are planning to link UAtom.org with social networks in order to outreach the younger generations as well as planning to place our banners in the relevant web resources. Also, the Orphan Radioactive Sources section will be expanded and filled with new information on issues related to the safety and security of radioactive sources.

5. CONCLUSION

Despite the fact that UAtom.org was recently created, it is actively being utilized by relevant organizations to promote the safety and security of radioactive sources. This platform offers a unique opportunity to implement various tasks, especially related to outreach and communication with the general public. UAtom.org is a perfect tool for the public providing an opportunity for direct contact with competent experts on issues related to IRS. The web site has useful and knowledge based information which can improve the public's comprehension on the safety and security of radioactive sources. Moreover, it is necessary to apply maximum effort, so that after all existing vulnerable and orphan sources have been collected, it will be possible to minimize the probable recurrence of new vulnerable or orphan radioactive sources. To this end, there are State regulatory requirements which must be complied with and UAtom.org can be of great use to address this challenge.

Today, Ukraine is implementing the best international practices in the area of orphan sources management. At the same time, it is important to understand that the large number of the found sources is not a reflection of the fact that the system of control is ineffective. As a matter of fact, it is quite the opposite — it is because there is an effective search system in place. Moreover, Ukraine reports to the IAEA each and every found source. The State has chosen a straightforward and transparent policy on the issue: Ukraine always reports what it finds and makes the results available. Therefore, it is possible to minimize the problem and to ensure control. However, it is not possible to fully prevent the occurrence of vulnerable and orphan sources, although it is possible to reduce the level of probability. UAtom.org has proven to be a useful tool in doing so.

CONCLUDING SESSION

PRESIDENT'S FINDINGS*

H. Alkaabi

1. INTRODUCTION

This Conference, held in Abu Dhabi, 27–31 October 2013, was hosted by the Government of the United Arab Emirates, through the Federal Authority for Nuclear Regulation, in cooperation with the International Criminal Police Organization, the International Commission on Radiological Protection, the International Source Suppliers and Producers Association and the World Institute for Nuclear Security. It was attended by about 320 participants from 87 IAEA Member States, 1 non-Member State and 6 international organizations. Its purpose was to review current success and challenges in ensuring the safety and security of radioactive sources, and to identify means to maintain the highest level of safety and security throughout their life cycle, from manufacture to disposal.

The timing of the Conference coincided with the tenth anniversary of the endorsement of the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) by the IAEA General Conference. To celebrate this anniversary, the first and second sessions of the Conference provided a review of the history of events which led to the development of the Code of Conduct, discussed the current status of its implementation and looked at the ongoing challenges relating to the safety and security of sources.

2. BACKGROUND TO THE DEVELOPMENT OF THE CODE OF CONDUCT ON THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

Radioactive sources are used extensively throughout the world for a wide range of beneficial purposes, particularly in medicine, general industry, agricultural research and educational applications. The need to ensure the safety and security of these sources has been recognized for many years, and many Member States established regulatory infrastructures for that purpose. Even so, the occurrence of a number of serious accidents in the 1980s and 1990s led the international community to question the effectiveness of these controls.

* The views and recommendations expressed here are those of the President of the Conference and the participants, and do not necessarily represent those of the IAEA.

Consequently, the IAEA organized a number of specific international conferences to examine the issues and make recommendations. These included:

- — The International Conference on the Safety of Radiation Sources and the Security of Radioactive Materials, held in Dijon, in 1998;
- — The International Conference on National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials, held in Buenos Aires, in 2000;
- — The International Conference on the Security of Radioactive Sources, held in Vienna, in 2003;
- — The International Conference on the Safety and Security of Radioactive Sources: Towards a Global System for the Continuous Control of Sources throughout Their Life Cycle, held in Bordeaux, in 2005;
- — The International Conference on the Control and Management of Radioactive Material Inadvertently Incorporated into Scrap Metal, held in Tarragona, in 2009.

The first two conferences listed above took place primarily in response to the growing realization that inadequate controls over radioactive sources had led to some significant radiological accidents, some of which had caused serious injuries, even death, and/or severe economic disruption. These accidents had their origins in a breakdown or absence of proper regulatory control and were not a result of malicious intent. After 2001, concerns regarding the possible use of radioactive sources for malicious purposes led the international community to broaden the focus of discussions to consider also the need to strengthen controls over the security of radioactive sources.

The safety and security of radioactive sources was also included as an agenda item at:

- — The International Conference on National Infrastructures for Radiation Safety, held in Rabat, in 2003;
- — The International Conference on Nuclear Security: Global Directions for the Future, held in London, in 2005;
- — The International Conference on Effective Nuclear Regulatory Systems, held in Ottawa, in 2013;
- — The International Conference on Nuclear Security: Enhancing Global Efforts, held in Vienna, in 2013.

Other international initiatives, such as the Nuclear Security Summit held in Seoul in 2012, also emphasized the importance of safety and security of radioactive sources.

A major finding of the Conference held in Dijon in 1998 was that the IAEA should investigate whether international undertakings concerned with an effective operation of national systems for ensuring the safety of radiation sources and the security of radioactive materials, and attracting broad adherence, could be formulated. The 1998 General Conference of the IAEA, held immediately after the Conference in Dijon, requested the Secretariat to prepare a report for the Board of Governors on the matter.

The Action Plan on the Safety of Radiation Sources and Security of Radioactive Materials, adopted by the Board of Governors in September 1999 [1, 2], requested the Secretariat to initiate a meeting of technical and legal experts for exploratory discussions relating to an international undertaking in the area of the safety of radiation sources and the security of radioactive materials. This undertaking would address the establishment of regulatory infrastructures, national arrangements for prompt reporting of missing sources, national systems for ensuring appropriate training of personnel, national arrangements for management and disposal of disused sources, and arrangements for a response to the detection of orphan sources.

The meetings of technical and legal experts held in March and July 2000 resulted in the production of the Code of Conduct. As a result of decisions taken at those meetings, the Code of Conduct focused on sealed radioactive sources, was addressed to States and national regulators, and was non-legally binding. A range of provisions of the 2000 Code were relevant to maintaining control over sources, and some of those provisions explicitly referred to the needs of 'security'. However, in reality the focus was very much on incidents such as persons stealing shiny objects for scrap metal resale, with no consideration given at that time to possible use of sources for malicious purposes.

The IAEA Board of Governors approved the Code of Conduct in September 2000. The subsequent General Conference endorsed the Code of Conduct and invited Member States to take note of it and to consider, as appropriate, means of ensuring its wide application.

Following the events of 11 September 2001 and a questionnaire sent out to Member States in May 2002, it was agreed that the Code of Conduct should be revised to strengthen a number of security related and other provisions and to specifically address intentional, or malicious, misuse of radioactive sources. An open ended group of technical and legal experts was convened for the purpose, and met three times in 2002–2003. The resulting revised Code of Conduct was approved by the Board of Governors in September 2003 [3], and later that month the General Conference welcomed the Board's approval of the revised Code of Conduct and urged:

> "each State to write to the Director General [stating] that it fully supports and endorses the IAEA's efforts to enhance the safety and security of radioactive sources, is working toward following the guidance contained in the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, and encourages other countries to do the same" [4].

In effect, this comprised an invitation to Member States to make a political commitment indicating their intention to implement the Code of Conduct.

When the text of the Code of Conduct was approved by the Board of Governors, it was agreed that additional guidance on the provisions in the Code of Conduct relating to the import and export of radioactive sources was needed. The supplementary Guidance on the Import and Export of Radioactive Sources (Guidance) was drafted by an open ended group of technical and legal experts over the course of two meetings, approved by the Board of Governors and endorsed by the General Conference in 2004. Again, the General Conference encouraged States to act in accordance with the Guidance on a harmonized basis and to notify the Director General of their intention to do so as supplementary information to the Code of Conduct [5]. The supplementary Guidance was revised in 2011; the revised Guidance was subsequently endorsed by the Board of Governors and the General Conference [6].

In response to a recommendation from the Bordeaux Conference, in 2005, a formalized process for the exchange of information between States on implementation of the Code of Conduct and the supplementary Guidance was established in 2006. This process calls for international meetings every three years where States are invited to prepare and submit national reports on their efforts to implement the provisions in the Code of Conduct. Two such meetings have been held to date, in 2007 and in 2010, and this Conference in Abu Dhabi in 2013 represents the third such meeting. Participation at each successive review meeting has increased. The reports of those information exchange meetings are available on the IAEA web site.[1]

The Code of Conduct is the principal international instrument for both the safety and the security of radioactive sources. The Code of Conduct and the Guidance complement the existing Safety Standards Series, specifically the Basic Safety Standards, which were first published in 1962 and which have been

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[1] See http://www-ns.iaea.org/tech-areas/radiation-safety/code-conduct-info-exchange.asp?s=3.

regularly updated since then. Since 2004, with the growing awareness of the need for security, the IAEA has published the Nuclear Security Fundamentals and has established a hierarchy of nuclear security recommendations through the Nuclear Security Series of documents. These include:

(a) Two documents specifically related to radioactive sources:
  - IAEA Nuclear Security Series No. 11, Security of Radioactive Sources [7];
  - IAEA Nuclear Security Series No. 5, Identification of Radioactive Sources and Devices [8].

(b) Two other documents which include radioactive sources within their scope:
  - IAEA Nuclear Security Series No. 14, Nuclear Security Recommendations on Radioactive Material and Associated Facilities [9];
  - IAEA Nuclear Security Series No. 15, Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control [10].

3. ACHIEVEMENTS IN THE SAFETY AND SECURITY OF RADIOACTIVE SOURCES

The Conference enabled States to share a number of significant achievements since the approval of the Code of Conduct in 2003:

(a) To date, 119 States have made a political commitment with regard to the Code of Conduct, thereby reflecting a wide acceptance of the Code of Conduct as the primary instrument for the safety and security of radioactive sources. Eighty-four States have made a political commitment to the supplementary Guidance.

(b) National regulatory infrastructures have been strengthened and, in many cases where they previously did not exist, they have now been developed. As a result, the number of accidents leading to serious radiation exposure has notably declined.

(c) The formalized process, established in 2006, for States to report their progress in implementing the principles in the Code of Conduct is a useful mechanism for States to assess their continuing progress in implementing the provisions of the Code of Conduct, to identify further needs and to benefit from the experiences of others. According to this process, a total of 68 Member States submitted national reports for the Conference. The

Conference noted that the process of preparing national reports constituted a valuable self-assessment tool.

(d) Bilateral, regional and multilateral cooperation programmes have been established to assist in the establishment of regulatory infrastructures; to share experiences; to assist in the improvement of both the physical protection and security management of radioactive sources throughout their life cycle; and to build capacity for radiological emergency preparedness and response. The latter includes building an effective response capacity for dealing with radiological accidents, situations in which radioactive sources are out of regulatory control, and malicious acts involving radioactive material.

(e) Many States have implemented strategies for regaining control over orphan sources.

(f) Postgraduate educational programmes on the safety of radioactive sources and on nuclear security now exist in a number of States in different regions of the world, and training programmes for various professional groups involved in safety and security have been established with the aim of developing and maintaining the appropriate competences.

(g) Some States have established bilateral administrative arrangements to exchange information consistent with the supplementary Guidance.

(h) The IAEA's role in supporting States' efforts to improve the safety and security of radioactive sources was commended. Specifically, a number of States have availed themselves of the peer review and advisory services provided by the IAEA. These peer reviews have been particularly helpful in identifying the strengths and weaknesses of national infrastructures for safety and security of radioactive sources. IAEA Nuclear Security Series No. 11 [7] was cited by many participants as being useful in the development of national radioactive source security requirements.

4. FUTURE CHALLENGES

The Conference noted that a number of important areas remain to be addressed:

(a) Not all States have made a political commitment to the Code of Conduct, and some States which have done so have made little progress in implementing its provisions. Further, some States support the Code of Conduct but not the Guidance. Having committed to the Code of Conduct and to the supplementary Guidance, progress in implementing the provisions in these documents will only be achieved if commitment is translated into action.

(b) While the legal and regulatory framework addresses safety in many States, there are — despite some progress — often inadequate controls to ensure the security of radioactive sources.

(c) National infrastructures for safety and security of radioactive sources can exhibit weaknesses in the following areas:
- The empowerment, competence and effective independence of the regulatory body;
- The clarification of responsibilities in cases where there is more than one regulatory body with responsibilities for the safety and security of radioactive sources, and the establishment of arrangements to avoid or resolve potential conflicts where there is an overlap of responsibilities;
- The provision of resources for the regulatory body, ensuring in particular that arrangements with regard to funding, staff numbers and competence, training and equipment, are sufficient for the regulatory body to carry out its duties effectively;
- An appropriate national policy and strategy for the management of radioactive waste including disused radioactive sources;
- An appropriate national policy and strategy for the education and training of professionals involved in the safety and security of radioactive sources.

(d) Management of scrap metal contaminated with radioactive material continues to be a problem. Despite some progress in the area, the fact remains that a high proportion of the incidents reported to the Conference involved orphan sources mixed with scrap metal.

(e) Transport of disused radioactive sources to the country of origin or to a storage facility may be difficult because of the absence of certified Type B transport containers that are consistent with the requirements of the current Transport Regulations. The Conference looked forward to the foreshadowed availability of suitable containers.

(f) Financial and other liabilities have not yet been widely established for dealing with disused and orphan sources, and also with incidents and accidents involving radioactive sources.

5. RECOMMENDATIONS

5.1. The need for a legally binding international instrument?

Looking to the future, the Conference discussed at some length whether, based on the Code of Conduct and supplementary Guidance, a legally binding international instrument (i.e. a convention) should be developed on the safety and security of radioactive sources. Whilst recognizing the many advantages which might accrue from having a convention (particularly in terms of provision of resources by governments), participants nevertheless acknowledged that the existing voluntary arrangements had been recognized by 119 Member States and that significant progress had been made in improving the safety and security of radioactive sources as a result of those Member States following the recommendations of the extant Code of Conduct and supplementary Guidance. Many participants considered that this achievement should not be undermined, particularly since there was no guarantee that a convention would include the same detailed provisions as the current Code of Conduct; or that it would attract a similar number of Member States to those currently supporting the Code of Conduct. Furthermore, it was felt that the development and eventual ratification of such a convention and the implementation of its requirements would take much more time than had been the case with the Code of Conduct. Participants also expressed concern about how a convention might be introduced in parallel with the ongoing implementation of the existing Code of Conduct. There could also be conflicts in requirements which could dilute the effectiveness of existing safety and security provisions. Finally, it was noted that the issue of potential overlap with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) would need to be carefully negotiated.

Throughout the discussion, participants acknowledged that a global system of protection was required whereby the priority would be to promote the levels of consistency and sustainability in the management of the safety and security of radioactive sources. They recognized that whilst much had been achieved, more was needed. It was a matter of judgment as to whether these further improvements might be achieved through the 'Code of Conduct' or whether a legally binding 'Convention' should be the platform for this. One solution might be for the negotiation of a legally binding 'Convention' with the same level of detail as the 'Code', and with no diminution or diversion of resources currently allocated to implementing the 'Code' whilst the 'Convention' is negotiated and then subject to the lengthy process of ratification by States.

5.1.1. Recommendation

The Conference recommended that *the IAEA* should convene a working group to assess the merits of developing a convention on the safety and security of radioactive sources and to make recommendations. This would enable an informed decision to be made with regard to whether the Secretariat should seek Member State support for the development of a legally binding 'Convention'.

5.2. Long term management of disused sources

The Conference discussed various options for the management of radioactive sources at the end of their useful lives. These include:

- — Increasing the recommended working life[2];
- — Return to supplier/manufacturer[3];
- — Reuse or recycling;
- — Long term storage;
- — Disposal.

Participants accepted that a source does not become waste until it reaches the point when final disposal becomes the only viable option.[4]

Participants agreed that returning a source to its supplier is the preferred baseline management option for a source which has reached the end of its useful life. However, implementing this option requires the establishment of a safe and secure national interim storage facility, in the framework of a national policy for the management of disused sources. Returns also require funding to cover costs such as prior packaging and transport. When a disused source is replaced by a new source, this funding could be provided either within the framework of the sale contract for a new replacement source or through the establishment of financial provision when purchasing radioactive sources, particularly those in Categories 1 and 2, as defined by the IAEA. Identifying the supplier to whom a disused source can be returned is also not always straightforward due to the age of the source and the possibility that the manufacturer may no longer be in business: a backup option in the form of a storage or disposal facility should be available on either a regional or national basis. Importantly, any solution relating to disused or orphan sources must guarantee continuity of regulatory control. A significant challenge in enabling the use of such a facility will lie in overcoming any potential conflicts in regulations relating to transport, radiation, waste safety and security.

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[2] Recommended working life is a concept defined in Ref. [11].

[3] It was noted that in some cases particularly with older radioactive sources, the original supplier may no longer exist.

[4] The Joint Convention defines radioactive waste as "radioactive material in gaseous, liquid or solid form *for which no further use is foreseen* by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party" (author's emphasis) [12]. Further, Article 28 of the Joint Convention obliges each Contracting Party to "allow for reentry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources."

5.2.1. Recommendation

Additional guidance at the international level for the long term management of disused radioactive sources should be developed. That guidance should make recommendations with regard to, at a minimum, the development of a national policy (including the establishment of interim storage facilities), the organization of the return to suppliers (including related financial arrangements) and the interface with transport and waste regulations. That guidance may form supplementary guidance to the Code of Conduct. The Conference therefore recommended that *the IAEA* set up exploratory discussions to determine the appropriate way in which to address the issues.

As part of the baseline strategy of returning sources to suppliers, *States' licensing suppliers* are encouraged to strengthen their cooperation with recipient states and each other. Data on manufacturers and exported radioactive sources should be collected and shared.

The importance of providing pre-shipment notifications to the regulator(s) in the importing State (as recommended by the supplementary Guidance) should be reinforced by *exporting States*. Regulatory requirements worldwide should be harmonized to facilitate transboundary movement of disused sources and contaminated scrap.

Member States which have not yet done so are strongly encouraged to ratify the Joint Convention, as it addresses the management of disused sources. *The IAEA* is further encouraged to continue efforts to promote the ratification of the Joint Convention by every Member State.

5.3. Interrelationship of safety and security

The fact that safety and security measures have in common the aim of protecting people, society and the environment has been explicitly recognized by the General Conference, the Nuclear Safety Fundamentals and the Nuclear Security Fundamentals. The Conference called upon the IAEA Secretariat to continue its efforts to ensure coordination of its activities in nuclear safety and nuclear security and to encourage the implementation of a process to reconcile the interfaces between the publications of the Nuclear Security Series and the IAEA Safety Standards.

Before the current emphasis on the need to protect radioactive sources from being used for malicious purposes, security measures were generally considered to be a part of the safety measures to prevent accidental misuse. However, there has since been general acceptance that this view is no longer sufficient, although support for this revised thinking is not unanimous. For this reason, it has become eminently clear that neither term is sufficient in itself for the purpose of defining functions. National authorities and international organizations have struggled over the last decade or more with varying degrees of success to find ways whereby the need for both safety and security of radioactive sources can be addressed. Liaison and coordination between those involved are essential but they are not always sufficient; there must also be a willingness for a professional to work in an integrated approach with emphasis on taking sensible, informed judgments appropriate to the situation. This is particularly important where safety and security approaches may conflict, for example, when safety calls for openness while security demands confidentiality.

The Conference noted recent developments at the IAEA which have significantly raised the profile of nuclear security. In particular, the formation of the Nuclear Security Guidance Committee had provided a forum for all Member States to contribute to the development of guidance through the Nuclear Security Series; and the establishment of the associated Interface Group had provided a formal mechanism whereby potential conflicts between nuclear safety and nuclear security could be resolved by the appropriate experts from each discipline. Similarly, the approval of the Nuclear Security Fundamentals publication (IAEA Nuclear Security Series No. 20 [13]) by the Board of Governors and the upgrade of the Office of Nuclear Security to a Division confirmed that nuclear security was now recognized as a discrete and permanent function of the IAEA.

Participants acknowledged these recent positive changes within the IAEA with regard to the relationship between nuclear security and nuclear safety. There was an implicit expectation that these changes would apply equally to matters relating to the safety and security of radioactive sources.

5.3.1. Recommendation

In well established practices where there is no confusion over the responsibilities and obligations for safety and security, for example industrial radiography, nuclear gauges and well logging, *the IAEA* should consider publishing integrated guidance which addresses both safety and security.

5.4. Information exchange

The Conference discussed how the voluntary mechanism for reporting on the implementation of the Code of Conduct and the supplementary Guidance might be improved. The Conference concluded that there was merit in developing guidance for States in the preparation of their national reports. Such guidance would contribute to consistency in describing activity against all areas of the Code of Conduct in the national reports, thereby encouraging more comprehensive national reports. These, in turn, would increase the effectiveness of the next review meeting and facilitate the in-depth exchange of information, knowledge and experience. Another benefit would be a more precise identification of progress, challenges, gaps and needs for further assistance and cooperation. The self-assessment methodology and tools developed by the IAEA provides a good framework for developing this guidance. At the same time, the guidance for national reports should not be so onerous as to discourage States from submitting national reports, which is, after all, voluntary.

5.4.1. Recommendation

The IAEA, within the existing formalized process and in association with States, should develop more prescriptive guidance for States to self-assess their level of implementation of all provisions of the Code of Conduct and to prepare their national reports. In addition, *all States* that have committed to following the principles in the Code of Conduct should fully complete their national reports in preparation for each review meeting.

5.5. Adherence to the Code of Conduct and supplementary Guidance

The Conference considered that *the IAEA and all States* who have made a commitment to follow the Code of Conduct should encourage those States who have not made such a commitment to do so. In addition, the Conference recommended that *all States* should persevere with their efforts to implement the principles given in the Code of Conduct and the supplementary Guidance. With a view to this, the Conference recommended that *the IAEA* continue to arrange meetings, both regional and international, to review progress and encourage further development of national arrangements to implement those principles.

5.6. Regional cooperation

The Conference considered that the regional cooperation programmes that had taken place over the last years had been highly successful in helping States develop their infrastructures for the safety and security of radioactive sources. It therefore felt that these should, where feasible, continue, although it recognized the current difficulties due to the global economic situation.

5.7. Scrap metal inadvertently containing radioactive material

The Conference noted that the recommendation of the Tarragona Conference that an international agreement between governments to unify the approach to transborder issues concerning scrap metal containing radioactive material had not been realized, and recommended that further attempts should be made to act on this recommendation.

5.8. Orphan source search programmes

Noting that many States had successfully undertaken search programmes for orphan sources, the Conference recommended that such programmes should be continued. Those *States* that had not already started such programmes were encouraged to do so, drawing on the experience of other States.

5.9. Sustainability

5.9.1. Infrastructure

Many States have benefited from the technical support provided by the IAEA and others over many years. The purpose of these support programmes has been to build up the infrastructures within States, with the ultimate goal of the States becoming self-sufficient in dealing with radiation safety, and more recently, nuclear security. The Conference recommended that *the States* which had been recipients of this support should work towards this goal, and *the IAEA* should increasingly focus on providing peer review services in order to identify strengths and areas for improvement. *States* are recommended to make use of these peer review services for improving their safety and security infrastructure.

5.9.2. Facilities and equipment

The Conference recommended that States should ensure that the physical protection upgrades undertaken over the last decade or so at facilities in which Category 1 and 2 sources are located, including those for disused sources, are appropriately maintained.

5.9.3. Education and training

Postgraduate courses in radiation safety and nuclear security have now been established throughout the world, and the support for these provided by the IAEA should be maintained. *States* should ensure that training programmes for professionals should continue to be developed, with the support, as necessary, of the IAEA, and consideration should be given to the formal recognition of experts for radiation safety and nuclear security specialists working with radioactive sources. These human resource development initiatives might also be complemented by the establishment of national professional associations, recognized by the State, for radiation safety and nuclear security specialists.

5.10. Events involving radioactive sources

The Conference noted that the IAEA had historically produced many reports of accidents that had occurred with radioactive sources with the purpose of sharing the lessons to be drawn from them. That practice, however, had declined in recent years. Accidents continue to occur (albeit at a lower rate), and the Conference therefore recommended that *the IAEA* should continue to produce such reports.

5.11. Liabilities and financial issues

The existing international legal framework surrounding nuclear third party liability expressly excludes radioactive sources from its scope. Liability with respect to incidents and accidents involving radioactive sources, as well as management of legacy sources, is therefore unclear. Even if, at the national level, legal liability for an incident is clear, there are generally no provisions which ensure that funds are available for the compensation of victims. It is clear that further consideration of this complex issue is required, and the Conference recommended that it should be examined further by *the IAEA*. One possible solution would be for the IAEA to request the International Expert Group on Nuclear Liability to take up this issue.

5.12. Further guidance on security

Participants recognized the importance of the guidance included in IAEA Nuclear Security Series No. 11 [7] for the development of national regulations and requirements for the security of radioactive sources. The view was that IAEA Nuclear Security Series No. 11 remained broadly current, but guidance on insider threats and trustworthiness were identified as gaps needing further development. Participants recommended that *the IAEA* give appropriate priority to the process to address them.

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CLOSING REMARKS

P. Hahn, IAEA

Your Excellency and Conference President, Mr. Alkaabi, Ambassador of the United Arab Emirates to the IAEA, ladies and gentlemen.

It has been my great pleasure to witness and to take part in a number of thought provoking and dynamic discussions regarding the safety and security of radioactive sources this week. I am honoured to make the closing remarks at this Conference on behalf of the IAEA Director General; my Deputy Director General, Mr. Denis Flory, whom you heard during the Opening of the Conference; as well as my colleague Mr. Khammar Mrabit, Director of the Office of Nuclear Security.

As you have noticed before and during the conference, my Division and the Office of Nuclear Security have shared the Scientific Secretariat for this conference with the view to ensuring full coverage of all aspects related to the safety and security of radioactive sources.

Before my remarks on the substance of this week's Conference, I would like to extend my thanks to a number of groups and people who made this Conference possible and who made it such a great success.

To our hosts, the Government of the United Arab Emirates and the Federal Authority for Nuclear Regulation (FANR), I thank you for your warm welcome and gracious hospitality. As many of you know, it is no small feat to host and arrange the logistics for a conference of this magnitude. The terrific facilities you have been able to enjoy all week long are courtesy of the efforts of the United Arab Emirates and FANR. The staff and officials at FANR have worked cooperatively and tirelessly with the IAEA, since the Conference was first agreed, to ensure that all participants were warmly received in the United Arab Emirates, that your week here was safe and smooth, and that the programme of the Conference was well designed and executed. In particular, Mr. John Loy, deserves special thanks as the Chair of both the programme committee and the local organizers' group.

To the IAEA's Conference Services staff, you are the IAEA's silent force and have once again put forth the hard work needed to ensure that a conference of this magnitude and importance ran smoothly. I thank you for all your efforts and hard work, both at Headquarters in Vienna, and all week here in Abu Dhabi.

To the Conference Scientific Secretaries — Ahmad Al Khatibeh and Carlos Torres Vidal — and their staff — namely Hilaire Mansoux, Tom Alexander, Christina George and Brian Waud, the preparations for such a Conference began long before last Sunday. To all of you who have worked behind the scenes in order to ensure the success of the Conference, I would like to extend my thanks and appreciation.

To the Programme Committee, thank you for sharing your expertise and helping to craft a layered and detailed conference programme which successfully balanced safety with security.

To the chairs and rapporteurs, you kept us on time and on target throughout the week and provided clear summaries of the sessions and discussions in the Conference. Special thanks go to our local FANR rapporteurs, who augmented the team and provided additional insights.

To the speakers, the Conference is richer as a result of your contributions and we thank you for taking time out of your daily responsibilities to share your experiences, and to allow others to benefit from them. Presentations represented States on all continents as well as several non-government organizations to provide a wide diversity of topics and perspectives.

To you the participants, I thank you for your active involvement in the technical sessions, panels, and your informal discussions throughout the week. As Mr. Flory challenged you in his opening speech, I hope each of you will leave Abu Dhabi with a renewed sense of purpose and dedication to improving the safety and security of radioactive sources in your own countries and throughout the world.

I would like to recall why we came together in the first place and to summarize what was discussed during the Conference. This week, we gathered to take stock of progress made by States under the Code of Conduct on the Safety and Security of Radioactive Sources (Code of Conduct) since its approval in 2003, and to seek new and creative ways to enhance its strength as the overarching global instrument for the safety and security of sources going forward. In the past ten years, 119 States have written to the Director General of the IAEA to pledge their commitment to meeting the principles contained in the Code of Conduct. I hope that in the near future that number will include all States, both IAEA Member States and non-Member States.

Mr. Flory and other speakers pointed out that a political commitment to the Code of Conduct is important, and 119 States is quite an impressive number; but they also noted that there are additional needs and further work is needed. The real challenge lies in identifying those needs, prioritizing activities to address them and implementing the solutions into national frameworks. The IAEA has noted the recommendation to improve the guidance for reporting within the formalized process in order to better assist States. Without this hard work and the demonstration of tangible results, a political commitment is only words on paper.

Along these lines, we heard from various States about the progress and efforts made to ensure the implementation of all provisions of the Code of Conduct, as well as the remaining challenges. What remains clear is that the degree of implementation of the Code of Conduct remains varied from one State to the next. It is therefore incumbent on the IAEA, as well as the global community, to assist all States seeking support to ensure that the appropriate legal and regulatory infrastructure for the safety and security of radioactive sources is established in all States, and in a harmonized way.

While both safety and security responsibilities rest entirely with States, international cooperation efforts in these areas are vital. Safety and security may have different approaches, but one cannot be complete without the other. In fact, in many cases improvements to one will have an impact on the other because within safety and security, each of them resides as an essence of the other. Neither safety nor security can be whole or complete without the other. In this light, the legal framework, regulatory infrastructure and facility implementation should address both in a comprehensive manner which takes advantage of similarities while also addressing potential conflicts. Where possible, States should build upon existing safety capabilities to improve the security of their radioactive materials rather than seeking to establish new systems dedicated to security.

In this regard, the IAEA notes the discussion regarding the need for the IAEA to coordinate the various series of publications and guidance documents. As you know, following significant discussion and consultation, a decision has been taken to follow parallel series for safety and security, but with a clear intention to improve interface. For example the Nuclear Security Guidance Committee, established by the Director General last year, is discussing this exact topic as we speak with regard to specific guidance on the safety and security of radioactive sources. The safety committees will also discuss this later this year.

MAJOR CONFERENCE FINDINGS

Along with the items I have already noted, this week has generated discussion and debate on a number of additional topics which are to be addressed in the future.

Code versus convention

Views on the need for a legally binding convention for the safety and security of radioactive sources remain mixed and no clear consensus was achieved. On the one hand, a legal basis establishing an expectation by which regulators are assured of receiving the necessary resources to execute their functions is very compelling. However, the Code of Conduct, in its current format, has the support of 119 States, and this is a clear demonstration of widespread commitment to improving the safety and security of radioactive sources. The Secretariat remains committed to serving its Member States and is ready to undertake further discussions on this matter.

End-of-life management

The session on long term safe and secure management of disused sources and ensuing discussions served to illustrate the complexity of this issue, and the level of cooperation needed by all stakeholders — including policy makers, regulators, operators, and industry. While a number of possible solutions for end-of-life management were raised, including repatriation, recycling, in country storage, and disposal it was very clear that there is no ‘one size fits all’ solution for all States. The IAEA notes the need for further guidance in this regard in order to assist States to establish comprehensive solutions for the safe and secure management of disused sources.

The General Conference resolutions on safety and security have placed a high priority on radioactive sources.

The security of radioactive sources is a topic that continues to be on the world’s collective radar. Other international initiatives, including the upcoming Nuclear Security Summit in the Netherlands next March, where the highest levels of States and government will gather, the security of radioactive material would be a topic of strong interest. States will endeavour to make commitments to ensure the protection and control of high activity sources, in compliance with political commitments made under the Code of Conduct.

I would also like to draw your attention to two upcoming Conferences on Nuclear Forensics in 2014 and Cyber Security in 2015.

Among the upcoming important safety gatherings, I wish to invite you all to the second International Conference on Occupational Radiation Protection, which will be held in Vienna in December 2014. Use of radioactive sources in medicine and industry are non-negligible sources of exposures to ionizing radiation for the personnel of the associated facilities. I invite you to pass the information to all interested people in your countries, so that your national experience and challenges on this topic are well considered.

There is still a lot of work left to do for us to meet the provisions in the Code of Conduct. As you heard from IAEA staff on Monday morning, the IAEA stands ready with an ever improving suite of tools to support you. We have established the information management system RASIMS (Radiation Safety Information Management System) for safety and will be launching an equivalent information management system for security — Nuclear Security Information Management System —to help you to better understand the current safety or security situation in your specific country or region.

We offer Integrated Nuclear Security Support Plans (INSSPs) to help States to identify and implement priority security actions for the future. The IAEA offers peer review and advisory missions for safety and security, including the International Physical Protection Advisory Service (IPPAS) for radioactive sources, the Integrated Regulatory Review Service (IRRS) and the International Nuclear Security Advisory Service (INSServ). The IAEA offers a host of training courses and other activities to address the full spectrum of safety and security needs for radioactive sources.

Ladies and gentlemen, the concepts of safety and security for radioactive sources are not new. But it is my hope that the insightful presentations, animated discussions and interactions in which I have been fortunate enough to participate this week have served to infuse each of you with renewed enthusiasm and commitment. I hope that you carry this renewed desire home with you so that we can continue to make progress in our shared mission. In approximately three years' time, when we reconvene as part of the formalized process for sharing information on implementation of the Code of Conduct, I hope that we are able to report on further tangible progress in making radioactive sources safer and more secure.

With this joint objective ahead, and wishing you a pleasant trip back home (one that is both safe AND secure), I now declare this conference closed.

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Panel 1	W. RHODES	United States of America
Panel 2	W. RHODES	United States of America
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