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Safety of radiation sources and security of radioactive materials

Contributed papers

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FOREWORD

The International Atomic Energy Agency (IAEA), in co-operation with the European Commission (EC), the International Criminal Police Organization (INTERPOL) and the World Customs Organization (WCO), is organizing an International Conference on the Safety of Radiation Sources and the Security of Radioactive Materials, in Dijon, France, from 14 to 18 September 1998. The Government of France is hosting this Conference and facilitating its organization through its Commissariat à l'énergie atomique, Direction des applications militaires (CEA/DAM).

This TECDOC contains the contributed papers dealing with the topics of this Conference which were accepted by the Conference Programme Committee for presentation. The papers are in one of the two working languages of this Conference, English or French.

The IAEA is planning to issue proceedings of this Conference containing the invited presentations, rapporteurs and Chairpersons overviews and summaries, conclusions and the highlights of the discussions.

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THE REGULATORY CONTROL OF RADIATION SOURCES, INCLUDING SYSTEMS FOR NOTIFICATION, AUTHORIZATION (REGISTRATION AND LICENSING) AND INSPECTION

(Technical Session 1)

IAEA-CN-70/80

LA FOURNITURE ET L'UTILISATION DES RADIOELEMENTS ARTIFICIELS EN FRANCE

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Résumé:

Plusieurs réglementations sé complètent pour garantir que les radioéléments présents sur le sol français sont détenus et utilisés dans de bonnes conditions, en particulier au niveau radioprotection. La Ciréa en asure la cohérence en donnant son avis sur les questions générales que soulèvent l'application de la législation. Elle asure un rôle réglementaire en posant des conditions particulières pour certaines pratiques. Les autorisations de mise sur le marché de sources et d'appareils en contenânt, d'utilisation, de fourniture... sont données directement par elle ou après avoir recueilli son avis.

La France a commencé dès les années 30 à se préoccuper des conséquences de l'utilisation de radioéléments. Une réeglementation a été élaborée à la fin des années quarante, conduisant à une loi adoptée le 19 juillet 1952, qui régit toujours la production, la commercialisation, l'utilisation et l'import-export des radioéléments artificiels. La Ciréa en est issue.

1. La Ciréa : une commission interministérielle

Ciréa, pour Commission Interministérielle des Radio Eléments Artificiels, est le nom donné à l'organisme contrôlant la fourniture et la détention des radioéléments artificiels sur le territoire français. Son existence découle du Code de la Santé Publique (article L 633), son organisation et ses missions étant précisées dans les articles R 5230 et suivants du même Code.

1.1. Composition

Sous la présidence d'un Conseiller d'Etat nommé par arrêté du Premier Ministre, la commission comprend des représentants des ministères et des grande établissements publics concernés. La commission comprend en outre un secrétaire permanent nommé par le Premier ministre.

1.2. Organisation des travaux

Deux sections placées sous l'autorité du président de la commission sont chargées :

- la première, des questions concernant la médecine et/ou la biologie humaine
- la deuxième, des questions concernant tous les autres secteurs (agriculture, industrie, recherche autre que médicale...)

Au moins deux réunions plénières annuelles sont prévues. La commission et les sections, pour examiner des questions ne présentant pas de difficulté particulière et réduire les délais de décision, peuvent donner délégation à deux de leurs membres agissant conjointement.

1.3. Les missions

Aux termes de l'article R 5233 du Code de la Santé Publique, "la commission interministérielle, en séance plénière, formule son avis ou ses propositions sur toutes les questions d'ordre général que soulèvent l'élaboration et l'application de la réglementation relative aux radioéléments artificiels, et notamment :

- la préparation, l'importation et la fabrication de radioéléments artificiels sous quelque forme que ce soit,
- les conditions générales d'étalonnage, de détention, de transport, de vente, de distribution et du commerce de ces produits,
- les conditions générales d'utilisation des radioéléments artificiels et les mesures de protection contre les effets de leurs rayonnements,
- les règles générales selon lesquelles la publicité prévue à l'article L.635 peut être faite" (publicité en matière de médecine humaine ou vétérinaire).

Par ailleurs, pour ce qui concerne la deuxième section des "conditions particulières" peuvent être fixées par le président au moment de chaque autorisation individuelle, après avis de la commission.

2. La réglementation

2.1. Le circuit des autorisations

Toute personne physique ou morale souhaltant détenir, utiliser, préparer, importer, exporter ou commercialiser en France des radioéléments artificiels ou des appareils en contenant doit en faire la déclaration afin d'obtenir une autorisation. Cette autorisation est donnée pour une durée variable (cinq ans au plus) et elle peut être accordée à tout intervenent basé dans un pays de l'Union Européenne.

Pour le secteur médical, l'autorisation est accordée par le ministre de la Santé, après avis de la 1ère section de la Ciréa.

Dans le secteur industriel, l'autorisation est accordée par le président de la Ciréa, après avis de la 2ème section. Dans la pratique, pour les cas qui ne présentent pas de particularités notables, l'autorisation est accordée par le secrétaire permanent de la Ciréa, agissant en tant que délégataire. Les autres cas, par exemple l'emploi de radioéléments pour des utilisations nouvelles ou dans des conditions inhabituelles, font l'objet d'une délibération en commission plénière.

Lorsque les raisons ayant motivé une autorisation ont cessé d'exister, l'utilisateur doit en avertir le Secrétariat de la Ciréa, qui donne des orientations si besoin pour la reprise des sources et des déchets éventuels. Lorsque la preuve est apportée qu'aucun radioélément n'est plus présent sur le site, l'autorisation peut être annulée.

Au quotidien, la Ciréa gère les autorisations délivrées en France, soit un total de prè de 5000 autorisations. Elle travaille sur la base des dossiers techniques fournis par les détenteurs de sources. Elle étudie les risques présentés par les appareils et les sources préalablement à leur commercialisation. Elle vise les formulaires exigés par la réglementation pour approvisionner des radioéléments (import, export, transfert européen, demande de fourniture en sources scellées ou non scellées). Les sources scellées sont suivies jusqu'à leur reprise par le fournisseur et le fabricant, ce qui exige la tenue à jour d'un fichier de plusieurs dizaines de milliers de sources.

2.2. Les réglementations connexes

Outre le Code de la Santé, diverses réglementations se complètent pour contrôler l'usage des radioéléments et garantie le respect des règles de sécurité et de protection sanitaire :

Les dispositions générales et les principes de radioprotection sont prévues par le décret 66.450, mis à jour par le décret 88.521. On y trouve notamment la liste des pratiques interdites (ajout de radioéléments dans des produits à usage domestique par exemple) et les niveaux d'activité impliquant une autorisation préalable. La définition des groupes de radiotoxicité, sur lesquels reposent les classifications actuelles, est donnée en annexe à ces décrets, de même que, pour chaque radioéléments, les limites annuelles d'incorporation par ingestion ou inhalation, exprimées en Bq.

Un décret (86-1103 et arrêtés connexes) régit la protection des travailleurs contre les rayonnements ionisants et les obligations des employeurs utilisant des sources radioactives ou des générateurs électriques de rayonnement.

Parrui les obligations qu'il instaure, on peut citer:

- l'information des travailleurs
- le suivi dosimétrique si besoin et le respect de limites annuelles d'exposition, en cohérence avec les recommandations de la CIPR
- le suivi médical des travailleurs
- la comptabilisation des entrées et sorties de radioéléments (registre)
- la nécessité d'un contrôle annuel des installations par un organisme agréé. Ce contrôle porte sur des aspects réglementaires mais également sur des aspects techniques, notamment la mesure du débit de dose ambiant ou l'étanchéité des sources
- le nécessité d'avoir pour chaque établissement une personne spécialement formée en radioprotection, qui doit avoir suivi une formation définie par arrêté et sanctionnée par un "diplôme" délivré auprès contrôle des connaissances.

Les organismes assurant le contrôle et la formation font l'objet d'un agrément ministériel périodique, donné habituellement pour des durées de un à trois ans.

D'autres réglementations s'appliquent à l'utilisation des radioéléments : on peut citer celles relatives aux Installations Classées pour la Protection de l'Environnement et aux Installations Nucléires de Base. Au cas ou les radioéléments sont soumis à un régime d'autorisation au titre de ces réglementations, le secrétariat permanent de la Ciréa n'intervient qu'après délivrance de cette autorisation par l'autorité compétente.

2.3. Spécificitées du secteur médical

L'utilisation de radioéléments en médecine ou pour des actes de biologie humaine a donné lieu à de nombreuses réglementations spécifiques.

- Si l'établissement commercialise des spécialités à caractère pharmaceutique, tels que des médicaments, des trousses de diagnostic ou des réactifs en radio-immunologie, l'avis de la Ciréa est communiqué à l'Agence du Médicament, établissement intervenant dans le cadre de l'article L 567 du Code de la Santé avant toute ouverture d'un établissement pharmaceutique ou toute mise sur le marché d'un nouveau produit. Son autorisation se substitue à celle délivrée au titre des radioéléments.
- Certains appareils de diagnostic ou de thérapie présentent des dangers potentiels pour l'utilisateur et pour le patient. Ils font l'objet d'une homologation préalable, mettant notamment en regard les risques et les bénéfices escomptés de leur utilisation.

- Des autorisations particulières, discutées en Commission, peuvent être accordées pour des phases d'essai et d'évaluation de l'intéret d'une nouvelle technique, au vu des protocoles proposées et an respectant les règles fondamentales d'éthique.
- En raison de leur cout, certains matériels de soin sont soumis à une "carte sanitaire" pour assurer une bonne répartition sur le territoire national tout en évitant les radondances.

La Ciréa doit tenir compte de toutes ces particularités et est souvent solicitée pour donner un avis au décideur final.

2.4. Spécificités du secteur industriel

Par rapport au médical, les circuits décisionnels apparaissent plus simples lorsque les radioéléments ne sont pas potentiellement à utiliser sur l'Homme. Par contre, les pratiques sont beaucoup plus variées.

La Ciréa a donc été amenée à édicter des "Conditions Particulières d'Emploi", qui sont notifiées à l'utilisateur. La grande majorité d'entre elles concerne la 2ême section bien que certaines sojent également applicables en 1ère section.

Ces conditions particulières sont apparues il y a une quarantaine d'années et restent un recueil vivant de prescriptions réglementaires, évoluant au fil du temps et des délibérations. Elles sont prises lorsqu'un point de portée générale est soulevé par un dossier ou lorsque des difficultés d'application de la réglementation sont révélées par l'usage. La plupart du temps, l'initiative en revient au Secrétariat Permanent de la Ciréa, qui se base sur son expérience quotidienne. Elles ont valeur réglementaire pour l'utilisateur à qui elles sont notifiées. Elles imposent des contraintes particulières pour l'emploi de radioéléments dans des utilisations précises, parfois avec des prescriptions techniques restrictives.

On peut citer, parmi d'autres, celles relatives aux :

- appareils de gammagraphie industrielle
- appareils portatifs hors gammagraphie
- détecteurs de fumée
- tubes électroniques
- peintures luminescentes
- utilisations du krypton liquéfié d'origine naturelle
- mesures du taux de renouvellement d'air dans un local
- traçages effectués pour l'hydrologie

Sans oublier les conditions particulières qui régissent la vie de la grande majorité des sources scellées et qui ont pour but de garantir, y compris sur le plan financier, la reprise de toute source par son fournisseur (ou un organisme agréé en cas de défaillance de ce dernier) après un temps d'utilisation normal de dix ans.

Il est bien sûr toujours possible de notifier, pour un dossier précis, des conditions particulières spécifiques.

3. Conclusion

La France a maintenant un retour d'experience de plus de quarante ans pour son système global d'autorisation des usages au sens large de radioéléments. Les principes de base ne semblent pas pour l'instant devoir être remis en cause mais il reste ouvert à toute évolution. En particulier, il doit s'adapter aux recommendations faites dans le cadre le l'Union Européenne qui conduit à une harmonisation des réglementations entre états membres.

REGULATORY ASPECTS OF RADIATION SOURCES SAFETY IN ALBANIA

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XA9848177

Abstract

In this paper are presented the regulatory aspects of the radiation sources safety in Albania, based in the new Radiological Protection Act and Regulations. The radiation protection infrastructures and procedures are described as well as their functioning for the implementation of relevant activities such as licensing and regular inspection, personal dose monitoring, emergency preparedness which are developed in the frame of the IAEA Technical Co-operation Programme. The issue of the security of radiation sources is dealt in close relation with the preparation and use of the inventory of all radiation sources in the country. A special attention is paid to the identification and location of lost sources for their finding and secure storage.

1. Introduction

The issues of the radiation sources safety and radioactive materials security have been paid a special attention in the country since the beginning of the use of nuclear energy for peaceful purposes. The first regulation on the safe handling of the radiation sources [1] had stated that "for the possession and use of the radiation sources it is obligatory that every legal person should have a special licence issued by the regulatory authority". On the other hand it was prohibited the transfer of the radiation sources between their owners without a written permission issued by the regulatory authority. Till to the end of '80 years the import of the radiation sources for all users had been centralised in Institute of Nuclear Physics. There was in functioning a special register for all characteristics of the sources and their users. This register served as official document for the control of radiation sources by the regulatory authority as well as the indicator of the sources state for all country. This situation had changed after 1990 when as result of the state decentralised policy, a weakness in functioning of these practises has been observed. In 1992 a RAPAT mission had visited Albania and recommended several measures aiming the improvement of the radiation safety situation of the country. This mission has concluded, inter alia, that "the legislation of the atomic energy application including radiation protection has to be revised in the near future and an infrastructure of radiation protection should be developed " [2]. Soon after the visit of the RAPAT mission, Albania was involved in the IAEA Technical Co-operation Programme through a special radiation protection project. This project aimed the preparation and issuing of a new radiological protection act as well as the furnishing of related equipment for implementation in the country of the different radiation protection procedures. Three years before Albania was included in IAEA Model Project "Strengthening of Radiation Protection and Waste Management Infrastructures". This Project, which now is under development intends to revise, update and upgrade nearly all radiation safety aspects in the country : legislation and regulations, national regulatory authority, radiation sources control, occupational radiation protection, emergency response, waste management [3].

2. Radiation Safety Infrastructures and Procedures

Based on internationally accepted radiation safety standards and on the particularity of the country, after a long and careful preparatory work of Albanian specialists in close co-operation with foreign experts, in the spring of 1995 a draft of New Radiological Protection

Act was prepared. This draft, after consultations with interested national organisations, was approved by Parliament in the end of 1995 (Law No. 8025, Date 9.11.1995). Based on this Act, some months later has been carried out the reorganisation of the National Radiation Protection Commission (NRPC) as national regulatory authority. As executive organ of the NRPC has been established Radiation Protection Office with full time limited staff. The first and most important task of the NRPC was the preparation of the radiation safety legal framework. Last year were prepared two regulations; the first for the licensing and inspections of radiation sources activities and the other for the safe handling of the radiation sources. After consultations with interested organisations and specialists, these regulations were consulted with IAEA experts. During these consultations the regulations were improved and became more consistent with BSS and other well-known international standards. Some months before these regulations were approved by the NRPC and now serve as the solid bases for the future related activity. Based on Radiological Protection Act and Regulations, a programme of licensing and inspection is prepared. Concerning the licensing, this process is foreseen to be preceded by the process of notification and registration. The process of the notification is obligatory for every legal person who intends to carry out the activities specified in Regulations, including the radiation sources that do not require authorisation. On the other side the notification is needed for the inventory purposes. The registration is carried out through the safety assessment of the practices or equipment and the information needed for this purpose, which indicates the legal person the location and use, responsible person for safety etc. For the licensing purposes the legal person declares through a special application form all necessary information to regulatory authority. This information contains the characteristics of the radiation sources, the purposes of the uses, the aggregate form of the source, the countermeasures in the cases of an accident etc. A detailed information needed also for the person responsible for the safety, like his qualification and working experience. Only after a careful examination of the data and inspection in situ, the NRPC decides to issue or not the licence. The licence is valid only for a limited period of time. Concerning inspection, the regulations give the rights to inspectors for exerting the duties and enforcement which comes from the legislation. Inspectors are in charge to inspect and to control in details the performed activity, to control all documents and registers, to take samples and to suspend the activity when exist sufficient data for radiological hazards toward workers, public or environment. Based in inspectors reports, NRPC can suspend or revoke the issued licenses toward different radiation activities with real or potential hazard. At the same time under the auspices of NRPC it is foreseen the preparation of the Codes of Practice, where the most important is the Code for Radiology and Nuclear Medicine, as the main man-made radiation sources activities of public exposures in the country. Another important task of the NRPC was the establishment of the National Radiation Protection BSS. For the preparation of these standards the IAEA BSS [4] have served as guidance document. For the moment the NRPC has approved the Exemption Levels and the Dose Limits for Occupational Exposures and for Public Exposures. Concerning personal dose monitoring of radiation workers, the first measurements belong to '70 years and were based in film photographic method. In 1986 this method was replaced by TLD, which is still in use. In the frame of the IAEA Project, a new Harshaw Reader 4500 was supplied last year, which technically can cover the monitoring of all radiation workers of the country. Much efforts are made to re-establish the medical examination of radiation workers in co-operation with Tirana University Medical Centre. This activity will be supported by the Project through the qualification of the relevant medical personnel. The prevention of the radiological accidents and the mitigation of their consequences are another important issues of the mentioned Project. For this purpose a draft of the national plan for radiological emergency response has been prepared and actually is in process of reviewing by the NRPC. This plan contents the general rules for radiological emergencies responses in the country as well as the operational intervention levels (OILs) in accordance to standards recommended by IAEA [5].

3. Security of Radioactive Materials

The security of radioactive materials is the main prerequisite to provide a good practice with radiation sources. The owners or users of radiation sources are responsible for their security [6]. They are obliged that radiation sources are adequately marked to indicate radioactive material and to provide their storage in a secure location such that people in the vicinity are not inadvertently exposed and that it is unlikely the sources could be removed by unauthorised persons. The security of the radiation sources is provided by their periodic control performed by the regulatory authority. The control of the radiation sources is another task which is foreseen in the working plan of the Project , which now is in the process of implementation. The first step has been the preparation of the inventory for all radiation sources in the country. As a solid base for this work served the mentioned-above register of imported sources for all the country . For the preparation of the inventory there were some difficulties related to: closing of many factories where the radioactive gauges existed, the import of radiation sources without written licence issued by the regulatory authority, the eventual transfer of the sources between the owners or lost of sources. For solving the mentioned questions a special questionnaire has been prepared and has been sent to all users by regulatory authority. Unfortunately not all the users were responded to questionnaire, while all other data were compared with existing register of imported sources. The updating of inventory dates especially for imported sources after 1990 were carried out through the co-operation with the General Custom Office. Standards forms used by Custom Office for import of any commodity contain for radioactive materials the international code number 2844.40. Last times all forms are computerised and therefore it was possible checking of declared radioactive materials imported into the country. By this co-operation was performed the control of the import of radiation sources, but when the sources were the parts of devices it was difficult or impossible their checking. On the other side exist the information that some foreign companies have entered radiation sources without authorisation by the regulatory authority for performing geological field researches and now it is difficult to verify whether the mentioned sources are turned back or not. The majority of radiation sources existed in the country were entered into prepared inventory, which was computerised through SRS programme in 1996. This inventory now is stocked in Institute of Nuclear Physics and in Radiation Protection Office. This year IAEA has prepared the RAIS Programme, where the first module is related to inventory of radiation sources. After its installation the work is concentrated in the transfer of the inventory data from SRS programme to the first module of the RAIS. The radiation sources security in the country became an acute problem last year, when as result of the attack toward military units there were lost or stolen many radioactive materials. Among them were some calibration sources of Co-60 with activity of 4 GBq (100 mCi) and Sr-90 in the form of metallic sheets with lower activity, but dangerous concerning internal contamination. Soon after that unusual occurrence, through the radio and television was given the information to the public for the lost radioactive materials and the explanations of the real danger which they represent for their health and especially for the children.

Radiation Protection Service of Institute of Nuclear Physics is in close co-operation with military services for location and turning back of the sources to military units. During the month of March were performed the localisation of a cobalt source in the southern part of the country. Through the monitoring of suspected area was carried out the map with dose rate distribution and later was been possible to detect the source [7]. After the careful digging and control of the soil, the source was found and transferred by special container to a secure location. A similar works is intended to be perform for the other lost sources, for which it is known the radioelement and the activity and to a certain degree the area of location. It is hoped that through an all-round and careful investigation of the different possessing data, collaboration with local administration and interested communities to conclude as soon as possible the process of turning back of all lost sources.

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REGULATORY CONTROL FOR SAFE USAGE OF RADIATION SOURCES IN INDIA

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Abstract

The widespread applications of radioactive materials and radiation generating equipment in the field of industry, medicine, agriculture and research in India necessitated the establishment of an efficient regulatory framework and consequently the Atomic Energy Regulatory Board (AERB) was constituted to exercise regulatory control over the safe usage of the radioactive materials and the radiation generating equipment.

The Atomic Energy Act, 1962 and the Radiation Protection Rules, 1971 promulgated under the Act forms the basis of radiation safety in India and Chairman, AERB is the Competent Authority to enforce the regulatory provisions of the Radiation Protection Rules, 1971, for safe use of radiation source in the country.

AERB has published a number of documents such as Radiation Surveillance Procedures, Standards, Codes, Guides and Manuals for safe use and handling of radioactive materials and radiation generating equipment.

Apart from nuclear fuel cycle documents, these publications pertain to industrial radiography, medical application of radiation, transport of radioactive material, industrial gamma irradiators, X-ray units etc.

AERB safety related publications are based on international standards e.g. BSS, IAEA, ICRP, ISO etc..

This paper outlines the methodology of regulatory control exercised by AERB for safe use of the radioactive materials and the radiation generating equipment in the country.

1. Introduction

In India, there is a widespread and continuous growth in the use of the radiation sources both radioactive materials and radiation generating equipment in the field of industry, medicine, agriculture, research, teaching etc. and the enforcement of the radiation safety in the entire gamut of applications of the radiation sources including their transport has been vested with the Atomic Energy Regulatory Board (AERB). So far as the medical application of the radiation sources in the country is concerned presently more than 800 medical institutions make use of radioisotopes for teletherapy, brachytherapy, nuclear medicine etc. including 219 telecobalt therapy units, 13 caesium teletherapy units, 45 remote after-loading brachytherapy units and Co-60/Cs-137 tubes needles for the intracavitary and the interstitial radiotherapy. In addition to the above, more than 600 nuclear medicine including the radioimmunoassy (RIA) laboratories, 19 medical accelerators and more than 35, 000 X-ray and CT medical diagnostic units are operating. The major industrial application of the radioisotopes is in the field of non-destructive testing i.e. the industrial gamma radiography and there are more than 925 gamma radiography exposure devices. About 100 industrial X-ray units including high energy accelerators are in operation in various places. Nearly 1000 nucleonic gauges incorporating very insignificant quantities of different types of radioisotopes are in use in level gauges, density gauges, thickness gauges, smoke detectors, well logging devices etc. Eleven high intensity gamma irradiation facilities are used for radiation processing such as sterilisation of pharmaceuticals, vulcanisation of rubber, sludge hygenisation, research etc. and three facilities are under construction for food preservation.

2. Regulatory framework

The regulatory framework for enforcing radiation safety provisions existed in the country since the inception of the atomic energy programme and is being constantly improved over the years to exercise effective regulatory control aimed for safe usage of the radioactive materials/radiation generating equipment. The Atomic Energy Act enacted in 1962 by the Parliament of India to provide for development, control, and use of atomic energy for welfare of people and for other peaceful applications forms main basis of the regulatory framework. The effective regulatory control over the radiation installations is ensured mainly by means of system of issuing Regulatory Consent in the form of licence, authorisation, registration and approval depending upon hazard.

a. The Radiation Protection Rules, 1971 (RPR)

RPR stipulates about 56 requirements for ensuring radiation safety which includes, inter alia, requirement of licence for handling radioactive materials, penalties for contravention of license conditions, the duties and function of Radiation Safety Officer (RSO) of each radiation installation, inspections of new and operating installations, issue of surveillance procedures by notification for specific practices etc. RPR is presently undergoing revision for incorporating the current radiation protection philosophy as outlined in the ICRP recommendations of 1990 and the Basic Safety Standard of IAEA.

b. The Atomic Energy (Safe Disposal of Radioactive waste) Rules, 1984

Radioactive waste management is based on the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1984. These rules cover aspects ranging from the processes resulting in generation of radioactive wastes to conditioning, storage and disposal of such wastes and provisions exists for hospitals and laboratories. The regulatory consent in the form of authorisation is mandatory for each person or installation prior to disposal of radioactive waste or for their transfer to a waste management facility.

c. The Atomic Energy (Control of Irradiation of Food) Rules, 1996

The above mentioned Rules comprehensively covers the regulatory consent requirements, the certification of the personnel authorised to handle radiation sources, the administrative procedures to be adopted for use of radiation sources, the technical conditions and the managerial aspects aimed at ensuring safety in the use and handling of the radiation sources, management of the radioactive wastes and the irradiation of food. These rules were promulgated 1991 which were later amended in 1994 and 1996 and these rules prescribe the technological conditions for the food irradiation, the qualification of the Radiation Safety Officer, the Operators and the Quality Control Officer, the various conditions for the operation of the irradiation facility, the dosimetry aspects etc. The Certificate of Approval is issued after verifying that the design of food irradiation facility conforms to the standards and qualified staffs are available for its safe operation. Under these rules, the Competent Authority, i.e. Chairman, AERB issues Certificate of Approval. Doses for onions, potatoes, frozen sea foods and spices are 60 Gy, 100 Gy, 5 kGy and 10 kGy respectively.

3. ATOMIC ENERGY REGULATORY BOARD

For effective enforcement of the various safety provisions for radiation sources to achieve high standard of radiation safety, an independent Atomic Energy Regulatory Board has been constituted by the Government of India in November 1983 by exercising the powers vested under the Section 27 of the Atomic Energy Act, 1962 to carry out certain regulatory and safety functions. AERB has powers to lay down safety standards for safety of radiation sources and issue surveillance procedures under RPR for specific practices such as industrial radiography, medical applications & transport of radioactive materials. AERB has set up an adequate Compliance Assurance Programme for enforcing all the radiation safety requirements. Chairman, AERB is Competent Authority to enforce radiation safety provisions in India.

4. RADIATION EQUIPMENT STANDARD

Most of the radiation generating equipment and devices containing radioactive materials such as gamma radiography devices, etc. are manufactured in the country and these equipment are required to comply with the AERB Safety Standards which specify the built-in-safety design features to be incorporated in the design, manufacture and its operations, Quality Assurance Programme, Probabilistic Safety Analysis etc. AERB has published Standard Specifications for radiation equipment such as medical X-ray units and associated accessories, telecobalt & brachytherapy units, medical accelerators, industrial radiography devices, etc. and these documents have been prepared by AERB on the basis of the international standards. AERB ensures compliance with these standards and it is an essential requirement for the equipment not manufactured in the country to adhere to these AERB standards if it is to be used inside the country. All radiation generating equipment are required to be type approved by AERB for use in the country. Demonstration of compliance with AERB standards is mandatory requirement for type approval.

5. REGULATORY CONSENT

The Competent Authority grants the Regulatory Consent in accordance with the provision of the Section 16 and 17 of the Atomic Energy Act, 1962 and the Rule 3 of the Radiation Protection Rules 1971 for handling radiation sources and the Consent is granted in the form of a licence, an authorisation, a registration and an approval depending upon the hazard potential associated with the different radiation sources. A licence is applicable to highest hazard radiation sources and mere registration to lowest hazard sources while the practices and devices using very small quantities of radioactive materials are exempted from Regulatory Consent e.g. consumer products and the Consent for high intensity gamma irradiators, high energy accelerators, medical teletherapy machines is in the form of licence valid for three years. Consent for brachytherapy, gamma radiography is issued in the form of authorisation while for diagnostic X-rays, nuclear medicine laboratories, nucleonic gauges, the registration in the form of consent is issued. Consent is issued at stages viz. manufacture, possession, use, transport, disposal, import, export or transfer of radiation sources and stipulates conditions such as validity, surveillance requirements, submission of periodic safety status reports to the office of the Competent Authority.

6. TRANSPORT OF RADIOACTIVE MATERIALS

The Radiation Protection Rules, 1971, the Radiation Surveillance Procedures for Safe Transport of Radioactive Materials (1980) issued under the above Rules and the AERB Code for Safe Transport of Radioactive Materials (1986) provides detailed regulatory requirements to be complied with for safe transport of radioactive materials in India. The Safety Code is based on the IAEA regulations for the Safe Transport of Radioactive Materials and the Code is undergoing revision to incorporate provisions of IAEA Safety Standards Series No. ST-1 on Regulations for the Safe Transport of Radioactive Material, 1996. The Centralised Emergency Preparedness Plans and Response Procedures involving transport of radioactive materials are established in the country.

7. INSPECTIONS AND ENFORCEMENT

The personnel authorised by the Competent Authority carries out periodic announced and un-announced inspection of radiation installations, equipment and transport packages based on the standard check lists available for each radiation practice and inspections are carried out for the site approvals, during construction, pre-commissioning, commissioning, routine operations and decommissioning of the facilities. In case of non-compliance with stipulated regulatory provisions, appropriate regulatory actions such as mere warning to the institutions, suspension of licence or its withdrawal, withdrawal of certificates of certified staff etc. are enforced according to the nature of violations and severity of the hazards.

8. RADIATION EXPOSURES TO OCCUPATIONAL WORKERS

As the regulatory body in India, AERB is responsible for adopting the radiation dose limits as recommended by the International Commission on Radiological Protection (ICRP) in the national regulatory framework and AERB has been issuing the Safety Directives from 1991 onwards to adhere to the recommended dose limits of ICRP 60 (1990) from previous recommended limit of 50 mSv/y in a phase manner. For the years 1991, 1992 & 1993 the annual dose limits were set at 40, 35 & 30 mSv respectively and the effective dose limit for radiation workers has been revised by AERB in 1994 such that the cumulative effective dose constraint for five year block, 1994-98, shall be 100 mSv for individual worker. The annual effective dose to a radiation worker in any calendar year during the five year block shall not exceed limit of 30 mSv and enough time to modify systems for compliance with limits has been given. It has been stipulated that dose constraints for optimisation in respect of future radiation installations including under design is 20 mSv in a year for occupational workers and 1 mSv in a year for public. Effective dose exceeding 20 mSv in a year is considered as an investigation level.

9. UNUSUAL OCCURRENCES

In spite of the strict regulatory control on supply, use, disposal and transport of radiation sources, a number of incidents have taken place in the country mostly in industrial radiography due to non-compliance with the stipulated safe work procedures for each practice which lead to improper servicing & maintenance of radiation equipment, human error, not making use of radiation survey instrument and carelessness of workers. However, very few of these incidents involved serious radiation injuries/excessive exposures to radiation workers and the public and the majority of these incidents involved in using Ir-192 sealed sources while only a few incidents are reported in the field of medicine and in the transportation of the radioactive materials. It is mandatory requirement for the user to inform Competent Authority about occurrence of unusual incident and AERB deputes its emergency team, if required, to the incident site for handling emergency. Remedial measures are suggested to all similar type of radiation installation to avoid recurrence.

10. CONCLUSION

Radiation Protection Programme is in existence since inception of nuclear programme in the country. Today, an adequate regulatory infrastructure is in existence to ensure radiation safety in various applications. Nevertheless, regulatory programme is constantly reviewed taking into account experience, newer national/international standards etc. and every effort is made to make the programme more effective.

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THE STATUS QUO, PROBLEMS AND IMPROVEMENTS PERTAINING TO RADIATION SOURCE MANAGEMENT IN CHINA[1]

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Abstract

Early in 1930s , radiation sources was used in medicine in China, and since then its application has been widely extended in a variety of fields. This paper presents a brief outline of the status quo , problems on management for radiation sources , and some relevant improvements as recommended by author are also included in it .

1. The status quo of application and management for radiation sources

In the 1930s , Peking Union Medical College Hospital imported a Rn generator for medical treatment , and the technology of radiation sources was quite limited in application . In the mid 1950s , China began to develop its own nuclear industry , promoting radiation sources being used in sectors such as medicine , geologic exploration , industry , agriculture and research and most of these sources were introduced from the former Soviet Union , the radioactive nuclides involving Radium-226 , Cobalt-60 , Caesium-137, Strontium-90 , etc.

Thanks to the start-up of the first research reactor in China in 1958 , radioisotopes and radiation sources could be produced locally to meet the need in various fields . 1970s saw a rapid increase in production of radioisotopes and sealed radiation sources, aimed at early self - sufficient both in assortment and quantity.

According to a preliminary survey[1] in 1995 , radiation sources in commissioning in the country amounted to 16,141 , 1992 taken as a base year , with about thirty percent of users of sealed radiation sources excluded in that statistics as estimated by experts . In fact , the sealed radiation sources in use could amounted to over 23,000 , which means the existence of the radiation sources users all over the country except Tibet Autonomous Region . The involved radioactive nuclides include Cobalt-60 , Caesium-137, Radium-226 , Amricium-241 , Iridium-192 , Californium-252 , etc. They are used in a variety of sectors such as industry , agriculture , research , medicine , geologic exploration and education . Table I shows the applications of the typical sealed radiation sources in 1992.

In 1980s , Chinese government established a few laws and regulations on radiation protection, radioactive waste (arising from application of nuclear technology) management , and on the production and application of radioisotopes and radiation sources , such as Regulations for Radiation Protection (in 1987) , Management Criteria for Radwastes from Nuclear Technology Application (in 1987) , Regulations for Protection against Radioisotopes and Radiation-Emitting Apparatus (in 1989) , Management Rules for Radiation Environment (in 1990) , and Environmental Policy of China on Intermediate - and Low - Level Radwaste Disposal (in 1992) . These regulations enhanced the management level for radiation sources in order to minimize any potential risk to the public caused by sealed radiation sources out of control , National Environmental Protection Agency (NEPA) was appointed by the central government in 1982 to take the responsibility of constructing a facility in every province all

[1] original title of this paper is The present Status, problems, and Improving Suggestions on Management for Radiation Sources in China

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Tab.I The applications of several typical sealed radiation sources in 1992 [1]

nuclides	number of user	number of sources	gross activity
Co-60	966	2647	4.90E+16
Cs-137	1663	4520	5.46E+14
Ra-226	341	1471	3.31E+14
Am-141	313	607	5.57E+13
Ir-192	118	202	2.98E+14
Pu-239	76	270	7.72E+10

Tab. II Radiation sources accidents leading to public death

year	site	cause	death number
1963	Anhui province	source stolen	2
1985	Heilongjiang province	source lost	1
1992	Shanxi province	source out of control	3

over the country for temporal storage of radioactive wastes and spent sealed radiation sources arising from radioisotopes applications . Now there are 19 such depositaries in operation which have been constructed by NEPA in co-operation with local environmental protection bureaus . Up to now , these depositaries have collected over 280 t low- level radioactive wastes and over 13,000 spent sources , significantly mitigating the potential risk from the wastes and sources possibly out of control . At the same time , as regulated by NEPA, all nuclear technology users shall make environmental impact assessment with emphasis on the environmental impact caused by discharge of liquid and gaseous wastes and management of solid radioactive wastes .

In addition , the management for transportation of radioactive material has also been enhanced. NEPA staff have dealt with cases of smuggling uranium dilution product and the trans-border illegal transportation of radioactive contaminated metallic scraps from neighboring countries .

2. Problems in application and management of radiation sources

Tab. II shows serious accidents of radiation sources leading to public death in 1963 , 1985 and 1992 respectively , which were put into operation in 1960s and 1970s when the management for radioisotopes application was poor .

2.1 Problem 1 Lack of legal management before 1970'

Because of no regulations issued by the government for applications of radioisotopes and radiation sources before 1970s , no license or registration system could be established , resulting in some radiation sources out of control and accidents caused accordingly .

2.2. Problem 2 Lack of special systematic safety training

Before 1989 , many users of radiation sources had not been requested to accepted special systematic radiation protection training . Most of them often operated their sources only by their limited knowledge of radiation protection they had learned from text books or research papers . Even now , quite many users still just know a little about radiation protection or do not know what radiation protection really is .

2.3. Problem 3 Lack of regular inspection system for safe application of radiation sources

According to the regulations issued in 1989 the national regulatory body shall to make regular inspections for registrants and /or licensees of radiation sources . But some local regulatory bodies failed to perform their duties, so that some sources were lost control and undiscovered for some time .

2.4. Problem 4 Lack of serious and careful responsibility transferring system

In case that persons responsible for safe management of radiation sources leave their positions for some reasons such as retirement or transfer of post , the serious and careful responsibility transferring procedures have to be followed , therefore the safe management for radiation sources can be continued . Unfortunately, the procedures are often ignored in reality . The fact found in the Survey of Radioactive Pollution Sources accomplished in 1995[1] shows that some radiation sources keepers are ignorant of any information about some radiation sources under their control .

2.5. Problem 5: Some storage conditions for spent sealed radiation sources are poor

We also found some storage conditions for spent radiation sources in above mentioned survey [2] are quite poor. Two examples are as following :

Example 1: A Cobalt-60 with activity 5.55 E10 Bq was buried in the mortuary of a hospital; and

Example 2: An university stored 33 spent sealed sources in a cave without safeguards .

The wrong storage of spent sealed sources means serious potential risk to the public .

3. Recommendations to improve management of radiation sources

3.1. Complete and implement the national legal frame for radiation source management

Following IAEA publicationSafety Series 111-S-1 Establishing a National System for Radioactive Waste [3] , it is necessary to review and revise the regulations issued in 1989 to incorporate the IAEA recommendations into national framework for radioactive waste management and to draw a lesson from past accidents . Much attention shall be paid to the improvement of the registration and license systems in terms of a complete legal frame for radiation source management.

3.2. Establish a strict inspection system for registrants of sealed radiation sources

In order to eliminate the unsafe human factors for registrants of radiation sources, a comprehensive and strict inspection regulations shall be formulated . For any registrant with so many such factors to be corrected in a short period of time , the regulatory body is entitled to revoke or suspend its register qualifications .

3.3. Stringent management measures for disposal of spent sealed radiation sources

Since the radiation source accidents leading to public death or serious environmental pollution in past decades were mostly caused by spent sealed sources , stringent management measures have to be taken . For example , a spent source with activity exceeding a specified definite limit can not get permission for interim storage in the application facility of registrant and shall be sent to the provincial central depository . Those spent sealed sources to be buried in a wrong manner must be retrieved and sent to the central depository .

3.4. Special training and regular retraining necessary for registrants

In order to maintain a requested qualification for registrants in safe use of radiation sources , special training and regular retraining have to be conducted . Experience proves that special training shall be regarded as an essential prerequisite for an applicant to get register or license , and special retraining for the applicant to extend the register or license .The training material or textbook should be compiled by experts in radiation protection and radioactive waste management , and the latest achievements and information obtained in related fields included .

4. References

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ASSESSMENT AND IMPROVEMENT ON SYSTEM OF LICENSING FOR WORK WITH IONIZING RADIATION IN CHINA

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Abstract

The article outlined regulations, authorities and responsibilities for licensing in China. The health departments at provincial level issue the license certificates to the units engaging in the production, use or sale of radioisotopes or apparatus equipped with radiation source or radiation-emitting apparatus, and have the duty of supervising and monitoring the security about radiation work. For the particular dangers of radiation sources, there is deficiency and shortage of the current licensing system, such as ignorance of the importance of keeping detail records about sources, poor communications among every health department, poor actions to prevent illegal and secret radiation work such as secret use and sale. We are going to improve our licensing system by hardware (computer technology) and software (management).

The most difference between radioactive work and other work is that radioactive work requires special security, being determined by the characteristic of radiation. In China, several departments, including health department, public security department and environmental protection, administer different aspects of radiation work. Health department have the duty of safety about radioactive work such as production, use or sale of radioisotopes and radiation-emitting apparatus, in order to decrease the danger to low levels which people can accept.

1. Regulations, authorities and responsibilities for licensing

In order to strengthen the supervision and management of radiation protection concerning radioisotopes and radiation-emitting devices, the State Council of China promulgated (Regulations for Protection Against Radioisotopes and Radiation-Emitting Apparatus) in 1989 as its No. 44 Decree to ensure the health and safety of radiation workers and the public, to protect the environment, and to promote the application and development of technologies concerning radioisotopes and radiation-emitting devices. The Decree No. 44 provide that the State apply the system of licensing and registration for radiation work including production, sale and use. The license certificates ought to be handled by health departments of provinces. Any unit, before engaging in the production, use or sale of radioisotopes or apparatus equipped with radiation source or radiation-emitting apparatus, shall apply for a license from the health department of its own province.

Therefore, the health departments also have the duty of supervising and monitoring the security about radiation work. At the average level, each department of provincial level (including its underlings) reissues 400 license certificates, checks 2000 license certificates, and monitors 2000 X-ray diagnostic machines, 100 CT machines, 400 industrial X-ray or γ-ray machines, 20000 radiological spots and 6000 radiation workers. It is a busy work for each provincial health department to execute above tasks. As an example, for new or changed radiological work, the unit will be required applications of radiation protection separately for 4 periods of choosing location, designing and building, completion and decommissioning, which being a most important gist for licensing.

According to the report from "Annual Bulletin of Health Inspection 1997" of China, 59336 units engaged in radioisotopes and radiation-emitting apparatus were registered, including 8858 units in radioisotopes, 50446 units in radiation-emitting apparatus and 12 nuclear establishments, 52722 licenses were held by the units and 24 radiation accidents occurred. The health inspection report comprises of food hygiene, occupational health, school health, environmental health and radiation hygiene. The report as a long data table about radiation hygiene only occupying a small partition but an important partition.

2. Deficiency and shortage of the current licensing system

The license including its appendix provide details about radiation work such as the sources, the name and type and manufacture of apparatus, movement of the sources, and so on, but only being kept by the unit of production and use and sale. For some administrative reasons, the health departments are seldom aware of the importance of keeping these detail records. So it often makes work of monitoring and checking sources deficient and careless.

There are poor communications among every health department at this field of special and technical management. And the State Ministry of Health doesn't know the details of sources and apparatus and other subjects all of the units, especially the unit of producing sources or apparatus. The accurate information about radiation work is only the above Report (table) of every year. We can do preventive supervision good for legal units but can't do anything to prevent illegal and secret radiation work such as secret use and sale.

3. Coming improvement for licensing system

Radiation sources are provided with particular dangers. We hope we can prevent illegal and secret radiological actions. During the Information Times, we can make full use of the latest achievement of computer technology. We are going to establish a database for the licensing system of the whole country and to develop regular communications among health departments and the Ministry of Health, especially about sale and movement of sources.

The database will help keep detail records about radiation work, and help gather all information of the whole country so as to make the Ministry of Health grasp the whole conditions of radiation work of the whole country.

We plan to establish a large licensing system for radiation protection of whole country with most popular Multi-Media by ACCESS. And the use of Internet will be a very important supplement. It will much facilitate the data link and the information exchange among relevant departments. And these will improve our management quality and safety in radiation fields.

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EXPERIENCE OF WORK WITH RADIOACTIVE MATERIALS AND NUCLEAR FUEL AT THE REACTOR WWR-K.

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Abstract.

In the report there are considered questions concerning the handling with fresh and spent fuel, experimental devices, containing high enriched uranium, being fissile materials of the bulk form, radioisotopes, obtained in the reactor, and radioactive waste, formed during the operation of the reactor, and organization of storage, account and control of radioactive and fissile materials is described.

1. General information

The research reactor WWR-K was put into operation in 1967 and operated during 21 years, in 1988 it was shut down for seismic- resistant measures. After completion the reactor was reactivated in 1997.

The reactor WWR-K is heterogeneous, water-water on thermal neutrons, its thermal power is 6 W. Fuel element assemblies, (FEA), contain uranium, enriched by isotope U-235 up to 36 %. The critical mass is 4.5kg of U-235. The operation of the reactor is cyclic (8-12days) with 4-5 - days stops for loading of the core.

The reactor has a large number of irradiation channels, being in the centre and at the periphery of the active core, in a tank of the reactor and in biological protection. There are available also 6 horizontal and 2 tangential channels. The maximum density of a thermal flow in the central channel of the active core is $1{,}4 \cdot 10^{14}$ n $cm^{-2} \cdot s^{-1}$, [1]. A wide range of density of neutrons flow allows to carry out research works in fields of material structure, solid state physics, activation analysis, radiobiology and many others.

2. Organization of work with radioactive materials.

a) Long time operation of the reactor has resulted in accumulation of a large amount of a radioactive material, which can be divided on following types:

- fresh and spent fuel;
- experimental devices (fresh and irradiated) containing highenriched uranium;
- materials of the bulkform with a different degree of enrichment;
- radioisotopes, obtained in result of irradiation of various samples in the reactor;
- control and reference sources;
- radioactive waste.

b) In each subdivision according to the order on Branch of Institute,, there is nominated the person, responsible for the account, reception, storage and distribution of radioactive materials.

The work with radioactive materials is permitted in specially equipped premises , having the sanitary passport, giving the right for work with radioactive materials of corresponding category [2].

The control for radioactive materials is realized by a service of radiation safety, supplied with stationary radiation-dosimetric control system and set of portable devices for the control of a radiation situation at working places.

A receipt of new radioactive materials from other organizations and a transference of them out of the Institute territory in other organizations are made by the permission of Institute administration, bodies of Sanitary supervision and Management of Internal Affairs Republic of Kazakstan. At receipt or dispatch of fissile materials, besides indicated above, a consent of Kazakstan Atomic Energy Agency (KAEA) is necessary also.

The radioactive materials, obtained by irradiation in the reactor , are given out to the responsible persons together with the accompanying passport, signed by the person, who gave out the material, and by dosimeterist, determened a gamma - equivalent of a source and transport category. The distribution of irradiated materials to the customers is registered in the book of distribution of irradiated production by an irradiation service and is registered in the special book in subdivision or laboratory, received a radioactive material.

The transfer of materials between subdivisions is made through responsible persons on the requirement, signed by the chiefs of both subdivisions, and put a visa by a service of radiation safety. After termination of date of operation the radioactive sources are written off by the act and are handed in for burial. The fissile radioactive materials are not subject to burial.

3. Storage of radioactive materials

3.1. Storage of fresh fuel

For storage of a stock of fresh fuel, two storage are intended, they are located in the ractor hall.

Norms, an order of storage of fresh fuel, equipment of storage by devices and signal system, and also the norms and an order of transportation of fuel are reflected in the Instruction on transportation and storage of fresh and spent fuel. The premises are equipped by dosimetric and security signal system..

Conditions of fresh fuel storage at the reactor WWR-K satisfy nuclear safety requirements and exclude an opportunity to create nuclear-dangerous situation, [3].

3.2. Storage of spent fuel

The spent fuel during its inloading out from the reactor is high-intensity source of ionizing radiation with high residual energy release. For spent FEA storage there are used wet storage filled by demineralized water.

There is regular monitoring for storage conditions, water level temperature in its.

Parameters control for water-chemical regime in storage is carried out periodically by sampling technique. The storage is joined up with separate system of filtrate unit.

3.3. Storage of irradiated experimental devices

After fulfilment of work programme irradiated experimental devices either are aparted in «hot chamber» or standing in temporary storages. For dry-storage there are used cooling channels. The channels are closed by covers and sealed. Irradiated experimental devices, allowing wet storage , are located in settling tank filled by water.

3.4. Storage of the bulk form materials

Fresh bulk form and non-irradiated experimental devices with nuclear material are stored in specially equipped storage. The conditions of storage satisfy nuclear safety requirements . The storage is equipped by dosimetrical and guard control system.

3.5. Storage of radioisotopes, control and reference sources

In laboratories and subdivisions of Institute dealing with radioisotopes there are safes for radioactive materials storage with protection from radiation sufficient for radiation safety ensurance at working places. The safes are closed and sealed up.

3.6. Radioactive waste Storage

During reactor technological process there are formed radioactive waste, for storage of which there is intended a post of burial of radioactive waste (PBRW) . It consists of underground storages, intended for long-term storage of middle- and poorly active waste, formed during reactor operation .

The burial area is fenced off and round-the-clock post of guards is organized.

4. **Organization of the account and control of radioactive and fissile materials**

The account and the control of radioactive and fissile materials are realized by conducting of special account system, the basic purpose of which is reception of the information about location and state of all radioactive materials amounts at any moment of time. The account, storage and transference of radioactive materials are conducted according to the operating Instructions confirmed by Institute Direction . Besides, the account, control and transference of fissile materials is conducted under the requirements given in the Methodlogical instructions of the KAEA and coordinated with the IAEA.

The reactor WWR-K and laboratories are considered as an united Material Balance Area (MBA) for account and control purposes.

Together with the Head of enterprise the responsible person for account and control is nominated by the order at enterprise and coordinated with the KAEA. This person directly performs all work on the account and control of radioactive materials.

Responsible persons for account and control of radioactive materials in laboratories and subdivisions are ones, nominated by the order or Almaty branch as responsible persons for account, reception, storage and distribution of radioactive materials.

The amount of radioactive materials can be checked up in operating documents, which at the reactor are:

- logbook of orders,
- cartogram of core charging with FEA numbers;
- cartogram of fresh FEA storage charging;
- passports for fresh FEA from manufacturer;
- cartograms of spent FEA storages ;
- logbook for reactor heat power registration;
- application for irradiation;
- working programmes.

In laboratories they are:

- passports for irradiated materials,
- the scheme of radioactive materials location in the safe;
- requirements for fissile materials reception ;
- acts of experimental devices putting in for irradiation;
- cards of experimental device moving;

In bulk form storage they are:

- cartograms of fissile materials location;
- list of fissile materials.

All other accounting documents are stored at the person responsible for the account in MBA or in a special department.

4.2. Inventory of radioactive materials.

Physical inventory of available amount of radioactive and fissile materials in MBA is carried out once a year. It has been done with following requirements given in the Methodological instructions of the KAEA to make physical inventory.

Moving of account materials is stopped during physical inventory making.

For radioactive sources without fissile materials the procedure of inventory consists in definition of accounted radioactive materials amount on accounting books and their real availability. Their activity is measured selectively for verification of amount of materials. The result of inventory is completed by special act. For fissile materials the procedure of the inventory includes:

- *fissile materials of accounted amount and their location definition under the* documents (accounting logbooks and cartograms),
- weighing of fresh fissile materials in bulkform, which have been in use,
- check of sender seals and stamps of the sender on packages, not having been in use,
- visual inspection of presence of products with irradiated fissile materials,
- selective measurements of irradiated experimental devices and spent fuel to define gamma-radiation of Cs-137 for differentiating them from irradiated mock-ups.
- check of seals on containers with fresh FEA,
- inspection of registered numbers of FEA and their location,
- verification of charging charts fop reactor, wet storages and spent FEA storage,
- verification of accounted amount with actual one.

On physical inventory data there is produced the list of real available amount of fissile materials to date of inspection.

Directly after the physical inventory IAEA inspectors will carry out verification of the Physical Inventory Listing (PIL).

All account information is stored in the computer and the hard copy.

The access to the documents on account and control of nuclear materials is made only under the permission of the Director of branch Institute.

5. Conclusions.

An experience of the handling with radioactive and fissile materials at the reactor WWR-K, accumulated during more than 20 years of operation of the reactor, has shown, that the existing system of technical and organizational measures is directed to prevention of accidental situations and unauthorized transfer of radioactive materials is quite reliable.

It is necessary to note the large help of the IAEA, rendered to the reactor during the last years. It concerns as to measures, directed on the whole to an increase of reactor operating safety, and to regulation and leading of procedures of the account, the control and storage of fissile materials to a conformity with international norms.

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IAEA-CN-70/25

The Regulatory Control of Radiation Sources, including Systems for Notification, authorisation (registration and licensing) and Inspection.

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ABSTRACT

Ghana was for four decades engaged in practices which involve the exposure of people to ionising radiation from man-made source without any national legislation to control them In pursuance of the Ghana Atomic Energy Act 204 of 1963, as amended by the, Provisional National Defence Council (PNDC) Law 308 and the enactment of further regulation, Radiation Protection Instrument LI 1559 of 1993, the Radiation Protection Board (RPB) was established to regulate the introduction and conduct of any practice involving sources of ionizing radiation in the country The RPB is thus the National Competent Authority for registration, licensing and inspection of practices in Ghana for the purpose of radiation protection and safety It has an inventory of all radiation sources in existence in the country as well as a system of control for their safe use

1. INTRODUCTION

Work with radioisotope in Ghana started in 1952 and had it's beginning in the University College of the Gold Coast (now the University of Ghana) where the initial experiments carried out involved the application of radio-strontium in monkeys By the close of 1959, work in radioisotope application in Ghana had sufficiently gained ground in a number of institutes as to make the establishment of a Radioisotope Unit a desirable venture [1]

In spite of the absence of a legislation, the National Nuclear Research Institute (NNRI) of the Ghana Atomic Energy Commission (GAEC) exercised some form of regulatory control over the use of radioactive materials and its storage

Due to developmental growth in the country use of radioactive materials spread to such areas as agriculture, hydrology, medicine, research, industry and environmental studies

The Government of Ghana through the Ghana Atomic Energy Commission, recognising the need to establish the basic requirement for the protection of people against undue radiation exposure established the Radiation Protection Board (RPB) in 1993 as the sole regulatory authority [2-4] The RPB has initiated a database for an inventory of all radiation sources either imported into the country or already in existence in the country as well as a control programme through a system of Notification, Authorisation by Registration and licensing and inspection

2. NOTIFICATION

Following the establishment of the RPB priorities were set to gain control over the procurement and use of radiation and radioactive sources in the country

In Ghana, notification of the RPB of one's intention to carryout any activity concerning radiation sources, X-ray machines and facilities, shielded enclosures and nuclear installations should notify the RPB in writing within the period of one month [5] Such notification forms can be obtained from RPB The RPB within one month will proceed with the assessment of the notification documentation The result of the assessment shall be

(a) Exemption (b) Request for application for authorisation
(c) Request for additional information or (d) Refusal

3. AUTHORISATION BY REGISTRATION/LICENSING

The applicant applies to the RPB for authorisation after assessment of the notification is completed The results of authorisation shall be
(a) Acceptance of the application documentation and proposition of pre-authorisation inspection
(b) Request for additional documentation (c) Refusal

The Authorisation by registration is issued only when all eventual corrective actions have been taken and confirmed by successive inspection

The authorisation by licensing takes the form of

(a) Provisional (b) Limited authorisation (c) Full authorisation

The RPB conducts periodic inspections at the facility to ensure that the conditions and terms stated in the authorisation and in the Safety Analysis Report (where applicable) are complied with

In exceptional cases, practices and sources may be exempted if the RPB is satisfied that the sources meet the exemption criteria Exemption will not be granted to permit practices that can not be justified [5]

4 DISCUSSION AND CONCLUSION

Notification alone is not sufficiently effective in regulatory control Notification is sufficient provided that the normal exposures associated with the practice or action is unlikely to exceed a level, specified by the Regulatory Authority (RPB) and that the likelihood and expected amount of potential exposure and any other detrimental consequence are negligible Authorisation through registration and licensing is more effective in regulatory aspect of protection and safety

With the promulgation of the legislative instrument the RPB is notified before possession of radioactive materials are taken There is also co-ordination between the Regulatory Body (RPB) and the Customs Authority (CEPS) in Ghana for the importation and control of any radioactive material or source that enters the country

TABLE 1 **SOME PRACTICES IN GHANA**

Application/Technique	Device/Source	Initial activity	Number notified	Number register	Number licensed
Medicine					
Radiography	X ray generator	-	130	100	-
Mammography	X ray generator	-	4	2	-
Tomography	X ray generator	-	1	1	-
CT	X ray generator	-	2	0	-
Brachytherapy	19 radium needle	370MBq	1	-	1
Nuclear medicine	Tc-99m	7GBq/2 wks	1	-	1
Teletherapy	Co-60	185TBq	1	-	1
Industry					
Surface gauges	Cs + Am	0 3+1 5 GBq	1+1	2	-
Thickness gauges	Sr-90	37-74 MBq	16	16	-
XRF	Cd-109	111 MBq	1	1	-
Gamma scattering	Cs-137	78 8 GBq	4	4	-
Neutron therm	Am-241	740 GBq	3	3	-
Oil well logging	Am + Cs	21 2 GBq	2+4	2	-
Hydrology					
No data available at present					
Agriculture					
Moisture gauges	Am-241	1 11 GBq	3	3	-
Research and teaching					
Diffraction	X ray generator	-	1	1	-
XRF	X ray generator	-	1	3	-
XRF	Cd-109	111 MBq	2	2	-
NAA	Am/Be	74 TBq	1	1	-
Liquid Scint Count	C-14	-	1	1	-
Irradiation	Co-60	266 4 TBq	1	-	
Irradiation	Co-60	1850 TBq	1	-	1
Calibration	X ray generator	-	1	1	-
Calibration	Co-60	3 7 GBq	1	1	-
Calibration	Cs-137	37 GBq	1	1	-
Calibration	Sr-90	18 5 MBq	1	1	-
NAA	Research reactor	10^{12} n/s	1	-	1
Miscellaneous					
Luggage scanning	X ray generator	-	3	3	-
Luggage scanning	X ray generator	-	2	0	-

The RPB verifies through notification and inspection that users of radiation sources and radioactive materials have properly stored their sources which are no longer in use With regard to radioactive waste that require more than one year decay period to bring down the activity level to below clearance, the waste generator is required to inform the National Radioactive Waste Management Centre (NRWMC) to collect and transport the waste from the generator's establishment for treatment, conditioning and storage at his/her own cost

Sealed Radiation Sources (SRS) Registry have been established by the NRWMC using the appropriate software provided by the IAEA The personnel have acquired adequate training from the IAEA and AFRA training courses and continue to attend meetings and workshops on SRS registry The inventory of the sources is regularly updated and made available for inspection by the regulatory body

More rigorous licensing procedures, in line with IAEA standards were applied to high level practices and sources in the country namely the 50KCi (1850TBq) Gamma Irradiation facility and the 30KW Ghana Research Reactor Although some facilities are registered and others licensed, operators of all facilities are licensed by the RPB after training and examination in radiation protection and related fields Facilities that are suitable for registration only include those for which safety can largely be ensured by the design of the facility and equipment, the operating procedures are simple to follow, the safety training requirement are minimal. Facility such as the Gamma Irradiator, Research Reactor are authorised by licensing

The RPB has an enforcement policy to correct non-compliance with regulatory requirements ranging from revoking of licence, fine or imprisonment depending on the severity of the offence

Any person or organisation who is aggrieved at the failure of the RPB to issue or renew any licence or considers the RPB has revoked or suspended a licence or attached any unreasonable conditions or limit to a licence may appeal to the GAEC If the GAEC is convinced that the person or organisation has been unreasonably treated he may request the RPB to take appropriate defined action

Even though Ghana has a very modest scale of application of radiation sources there is the need to put in place a mechanism for safety culture for protection against the harmful effects of ionising radiation and for the safety of sources which are on the increase due to developmental needs in the country

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SAFETY OF RADIATION SOURCES AND THE SECURITY OF RADIOACTIVE MATERIALS IN SAUDI ARABIA

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Abstract:

The present status of the safety of radiation sources and the security of radioactive materials in Saudi Arabia is reviewed in details. Hazards and potential threat, material control and responsible parties, in addition to management and the technical requirements, are the main topics that are discussed. Some interest is given to the responsibilities of the regulatory authority, with special emphasis on the role of King Abdulaziz City for Science and Technology as a national competent authority.

1. Introduction:

The uses of radioactive substances are widespread and still growing in different fields. The benefits gained due to these uses of nuclear technology in these fields determines the extent of risk acceptance by the society. Radiation safety standards, such as the I.A.E.A's International Basic Safety Standards (BSS) for protection against ionizing radiation and for the safety of radiation sources[1] have been developed and issued to restrict radiation risks and to ensure radiological safety. When the safety requirements of these standards are properly met, risks and radiological hazards are strongly eliminated. However, there are number of illegal movements of radioactive materials through and across States and State borders, that create the threat of terrorist actions and potentially serious hazards to public health. Many serious and fatal consequences have occurred as a result of unauthorized receipt, possession, use, transport or disposal of radioactive materials. In many instances, loss of control of radioactive materials has lead to serious fatalities[2-5].

Systems for safety and security of Radioactive sources in the Kingdom of Saudi Arabia are to be established and are considered as a basic requirement for protection against ionizing radiation. This paper presents the present status in the Kingdom.

2. Hazards and potential threat in saudi arabia:

In the Kingdom of Saudi Arabia, radioactive materials are manufactured, exported, imported, transported and used in industry, medicine, research, teaching activities and other fields. Some radioisotopes and radio-pharmaceuticals are produced at the research center of the King Faisal Specialist Hospital at Riyadh using the 28 MeV variable energy cyclotron. Part of these radioisotopes is used locally while the other part is exported. Moreover, different radiation sources are imported and widely used in different techniques. Many hundreds of different radioactive sources, such as Co-60 Tc-99m, Cs-137, Ir-192, Am-Be neutron sources and others with different activities are imported annually and used in different applications.

3. Basic obligation and responsibilities of principal parties:

In the Kingdom of Saudi Arabia, any radioactive source or material should be authorized in accordance with the basic obligation of the BSS for protection against ionizing radiation and for the safety of radiation sources. This obligation requires that no practice shall be adopted, introduced, conducted, discontinued or ceased and no source within a practice shall, as applicable, be mined, milled, processed, designed, manufactured, constructed, assembled, acquired, imported, exported, sold, loaned, hired, received, sited, located, commissioned, possessed, used, operated, maintained, repaired, transferred, decommissioned, disassembled, transported, stored or disposed off, except in accordance with the appropriate requirements of the standards, unless the exposure from such practice or source is excluded from the standards or the practice or source is exempted from the requirements of the standards. The Principal parties that are responsible for the adoption of the requirement of the BSS are; the competent authority, the licensee, the consignor, the carrier, and the local authorities. The general responsibilities of principal parties, within the requirements specified by the Regulatory Authority, are:

(1) The Competent Authority:

The Competent Authority has been firstly nominated in the Kingdom of Saudi Arabia in 1986, where, the Regulatory Authority has been divided in two main bodies. The Technical authority, which includes all technical and scientific aspects of radiation protection and safety of radioactive materials, together with preparation of regulations and instructions, was delegated to King Abdulaziz City for Science and Technology (KACST), where the most qualified personnel exist in the Institute of Atomic Energy Research. The enforcement authority has been delegated to the Ministry of Interior of the Kingdom. Other authorities have been distributed among others. For example, the Saudi Arabian Authority for Standardization is responsible for issuing different limits concerning radiation aspects. The Ministry of Commerce is responsible for detection of radioactivity in imported foodstuffs and consumer products. However, for effective regulations, it is hoped that the new act on radiation protection against ionizing radiation in the Kingdom will nominate a single regulatory authority, that will be supported by sufficient powers and resources for effective regulation and will be independent of any other governmental institutions or agencies being regulated.

Recently, KACST as a national competent authority, has prepared new regulations for protection against ionizing radiation and for the safety of radiation sources, which are in harmony with the international BSS issued in 1996.

(2) The licensee:

The licensee has the primary responsibility for the safe use, control and security of the licensed radioactive materials. It is his responsibility to prepare and maintain a detailed accountability system that includes complete records for all the licensed sources. The record should include description of each source or radioactive material for which he is responsible, such as its activity, quantity and form, its use location and movement and all measures that have undertaken to ensure security of the source.

(3) The Consignor and the Carrier:

For the safe transport of radioactive materials consignor and carrier bears safety responsibilities during transport. The consignor is responsible for complying with the national regulations related to the safe transport of radioactive materials. He should supply the carrier with all appropriate emergency instructions and schedules, and be ready to offer all needed assistance in an emergency involving the consignment. The carrier is responsible for complying with the national regulations, being informed of different response procedures along the route, and getting the proper emergency instructions on boarding the source.

4. Radioactive sources' control in Saudi Arabia :

The main elements required for control of radioactive materials and sources in Saudi Arabia include unauthorization for receipt, possession, use, transport, import, export and disposal of radioactive materials.

a) Authorization to possess radioactive materials

According to new Saudi regulations, possession, receipt or delivery of any amount of radioactive material should be authorized by the regulatory authority of the country. Up to now there is no exclusion from this requirement even for any small amount of radioactive materials. Clearance of any radioactive materials is done by the national regulatory authority. In the country, the term notification is not applied in that sense given in the international BSS. However, terms registration and licensing are both applied and require that authorization has to be obtained prior to receipt, possession, use and transport of radioactive sources and materials. An application for clearance of a radioactive material should include all information such as, i) type of the radioactive material and its quantity, ii) a description of the equipment and the type of practice in which the material will be used, iii) the location for use and storage and the identity of the individuals responsible for security and safety of the material.

b) Authorization to transport radioactive materials

According to the new Saudi regulations, transport of any radioactive material or waste should be subjected to the requirements of the safe transport of radioactive material, which is in complete harmony with the IAEA's regulations for safe transport of radioactive material. Appropriate packaging, adequate documentation and prior notifications by the producer and consignors are required to assure that the carrier takes appropriate precautions and to secure the arrival of the material.

c) Import or export of radioactive sources

When radioactive materials or sources are imported from abroad they are subjected to the custom's inspections. In Saudi Arabia, there is a complete coordination between the customs authority and the regulatory authority. Any amount of radioactive materials or sources will not be cleared from the custom's authority unless prior notification to this authority has been issued by the regulatory authority. The regulatory authority has issued a complete instructions to the radioactive material producers to stop any supply with radioactive materials unless the receiver has a valid authorization.

d) Authorization to dispose of radioactive materials

According to national regulations for handling of spent radioactive sources which are no longer in use, these sources should be returned back to the producer. If this is not possible, the sources should be collected by the licensee, conditioned for storage and safely and securely stored until a national authorized disposal facility will be available in the country. Soluble liquid radioactive waste may be disposed of to the common sanitary system under certain circumstances, which are dedicated to environmental protection and prevention of loss of control of radioactive material. The regulatory authority verifies periodically through inspections that users are properly disposing their radioactive waste.

5. Regulations for the security of the radioactive sources:

Some elements that are used to regulate radioactive sources and to assure their security and safety in the Kingdom of Saudi Arabia are :

A. Physical Security of Radioactive Material

Physical control of radioactive material which is in use or stored starts from the existence of; a) a clearly designated place for handling and storage, b) notices, signals or other warning means to identify the presence of radioactive materials, c) It should also include, controlled access to the place of usage and storage, d) guards or electric surveillance. Regular audits and assessments to check the security arrangements, warning notices, and safety systems, measurement of dose rates and contamination levels, etc. Particular effort is needed for radioactive materials in medicine, industry and research, where many such materials are used and stored and there are many individuals handling of the material.

B. Accountability for Sources and Records

The licensees authorized to possess, use, transport, import and export radioactive sources bear full responsibility for the radioactive sources and materials handled by them, and should maintain an accountability system, including records for each source. The record include; name, technical qualification, movement, physical and chemical state, serial number, location, and all other details including any activities in which the radioactive source or materials are used. Other records for shipments, receipt, physical inventory, operation losses and final disposition should be maintained.

C. Location of Sources

The selection of a site for a source that holds a large inventory of radioactive substances or has the potential for release of large amounts of such radioactive substances must take into account any features that might affect the safety of the source or might be affected by the source. The feasibility of off-site intervention, including carrying out emergency plans and protective actions as foregoing factors in engineering design must also be considered.

D. Inspection

Inspection is one of the major aspects that strongly affect safety and security of radioactive sources and materials. So, the regulatory authority reserves all rights to inspect all practices and actions that include radioactive sources or materials in periodic or sudden manner to ensure the compliance with requirements, and regulations of radiation protection. This includes inspection of used procedures for carrying out actions, all workers, all locations that may be affected by these actions or may affect them, and all documents and records relevant to the actions, radioactive materials and sources or persons and their radiation exposure.

E. Periodic Checks of Inventories and Notification of Loss of Control

Inventory of radioactive materials should be checked periodically to confirm that the materials are in their assigned locations and are secure. Records of the inventory and findings should also be maintained. The appropriate intervals for conducting inventories depend on considerations similar to those for security. The regulatory authority should be notified of the loss of control of radioactive material. The notification should include a description of the radioactive material and any associated equipment, its last location and the circumstances. The timings and means of notification will depend on the nature of hazard. In any case, initial notification should be prompt, so that the actions to regain control and reduce risk are most effective if started quickly. The regulatory authority have sufficient enforcement policy to correct non-compliance of requirements.

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ORGANIZATION AND IMPLEMENTATION OF A NATIONAL PROGRAMME OF REGULATORY CONTROL OF SOURCES IN ESTONIA.

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Abstract

The application of ionizing radiation and radioactive material in fields such as medicine, industry, teaching and research is constantly increasing. Consequently, any country using ionizing radiation and radioactive material in these applications must ensure that they are used safely.

In order to achieve this goal a country must establish appropriate national infrastructure related to radiation protection and safety. This requires appropriate regulatory mechanism together with an enforcement ability. The national infrastructure adopted in a country will depend on the actual needs of the country, the size and the complexity of the regulated practices and sources, as well as on the regulatory tradition in the country.

The national infrastructure in Estonia comprises of three main components

- Legislation
- Regulatory Authority
- Resources

1. Legislation.

The first step in achieving adequate control of safe uses of ionizing radiation and radioactive material in Estonia is establishing appropriate national legislation which provides a foundation for a regulatory program. The legislation bases on a general principles of radiation protection of people and safety of radiation sources.

1.1. Radiation Protection Act in Estonia was issued in 23 April 1997 which includes:

- principles of acceptability of activity involving radiation
- status of Radiation Protection Centre
- requirements concerning activity involving radiation
- radiation exposure categories
- exposure limits
- occupational exposure
- occupational exposure limits
- environmental natural exposure
- dose register
- age limitations for radiation work admittance
- health surveillance of radiation workers
- public exposure
- assessment of public exposure
- medical exposure
- emergency exposure
- securing of safety of radiation sources

- installation , repair and maintenance of the radiation source
- type approval of radiation sources
- transport and marking and labeling of radioactive substances, radiation equipment containing radioactive substances and radioactive waste
- definition of radioactive waste
- basic requirements for radioactive waste management
- restrictions in regard to transfer and take-over of radioactive waste
- export of radioactive waste
- state supervision
- special cases of application of the Act
- changes in former legal acts
- liability of a legal person for violation of the Radiation Protection Act

1.2. Subordinate legislation: lows, regulations, codes of practice, guides and manuals, which provide details of specific matters including :

- dose limits for persons occupationally exposed to ionizing radiation
- dose limits for members of the public
- licensing of persons / institutions to import, export, use, sell or prssess irradiating apparatus and radioactive material
- the form and manner of application for, and granting of, licences, their term of validity and fees to be charged
- registration of irradiating apparatus , sealed radioactive sources and premises in which unsealed radioactive material is used
- provisions for personal dosimeters and for dosimetric equipment
- requiring persons, suspected to have been adversely affected by ionizing radiation, to undergo medical examination
- requirements relating to the construction, or structural alteration, of buildings used for treatment, storage or use of radioactive material
- inspection of premises in which radioactive material is used, treated,
- manufactured or stored
- inspection of irradiating apparatus and radioactive material
- training of radiation protection officers

2. Regulatory authority.

The national legislation (Radiation Protection Act) nominates a national Regulatory Authority which is given responsibility for regulating any practices involving sources of radiation.
Estonian Radiation Protection Centre was established in January 1995. The general function and responsibilities of the Estonian Radiation Protection Centre include the following:

- the development of regulations, guides and codes
- the assessment of applications for permission to conduct practices that entail or could entail exposure to radiation
- the authorization of such practices and of the sources associated with them

- the conduct of periodic inspections to verify compliance with the license condition
- the enforcement of any necessary actions to ensure compliance with the regulations and standards
- keeping records of all sources of ionizing radiation
- keeping records all radiation doses received by radiation workers and make estimates of doses received by the public
- the preparation of plans and procedure for dealing with emergency/accidental situations
- the advise other national institutions, users of ionizing radiation and the public on radiation protection and related matters

As it is many other countries not having NPPs, the industry, medicine, and research are the main areas of the application of ionizing radiation in Estonia. Currently Estonia has over 420 different users of ionizing radiation sources.

Type of applications of radiation sources	**Number of users**
Sealed sources and x-ray equipment in industry	46
Sealed sources and x-ray equipment in research	10
Sealed sources in medicine	2
Smoke detectors	52
Unsealed sources in industry	1
Unsealed sources in research	9
Unsealed sources in medicine	3
Dental x-ray	192
X-ray in medicine	100
Storehouses	2

3. Conclusions.

As a country with no nuclear power plants, the nuclear safety concerns in Estonia are small compared to many other European countries. There are not currently plans in Estonia for construction of the NPP. As a result majority of regulatory activities is related to the licensing and inspection of ionizing radiation sources.

The legal framework for regulation of nuclear safety and radiation protection matters in Estonia takes into account relevant IAEA documents.

In spite of this framework it turned out that the setting-up of the final legislation and the Regulatory Authority organizational structure is long , time consuming and a complicated process.

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REGULATORY CONTROL OF RADIATION SOURCES IN GERMANY

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Abstract.

The regulatory programme governing the safe use of radioisotopes in Germany is based on the federal legislation enacted as ***Atomic Energy Control Act (Atomgesetz)*** *and* ***Radiation Protection Ordinance (Strahlen-schutzverordnung)*** *and its implementation by the competent authorities of the individual states. Despite this highly decentralized infrastructure of enforcement the basic principles of regulations described in this paper such as authorization criteria, conditions imposed as well as depth and intensity of inspection balanced according to the individual radiation hazard involved are harmonized to the greatest possible extent by regular coordination among the competent authorities as well as a series of technical regulations such as standards and guidelines.*

1. Legislation

The Radiation Protection Ordinance establishes the basic regulations for the safe use of all sorts of sources of ionising radiation within the framework of the Atomic Energy Control Act. These per-formance oriented regulations specify the type of radioactive practices which require licensing, notification or are exempted from authorization procedures. They set dose limits for workers and the public and prescribe the requirements for personnel, health surveillance, dosimetry, emergency handling, transportation, waste disposal, records etc.

Legislative requirements are supplemented by prescriptive technical regulations, i.e. standards and guidelines such as quality assurance, shielding, safety control systems, isotope laboratory specifi-cations, internal and external dosimetry, safety evaluation of sealed sources etc.

2. Enforcement

Except for high-activity-transports, import/export and spent nuclear fuel management all regulatory programmes are implemented by the competent authorities of the States (Bundesländer) empowered by their resp. governments.

Thus the organization of the regulatory items differs from state to state with the activities

- licensing of transportation and use of radiation sources
- inspection
- waste disposal
- approval of sources and equipment for exemption from licensing
- official external and internal dosimetry

being enforced by one or more of the following authorities or institutions:

⇒ State Ministry
⇒ State Office for Environmental/Occupational/Radiation protection
⇒ State Office of Mines
⇒ District Governments
⇒ industrial or occupational regional inspectorates
⇒ institutions for dosimeter evaluation and incorporation control.

At least once a year experts of all State Ministries and the Federal Ministry meet in order to harmo-nize the regulatory aspects being reported by the regional authorities. Decisions of this committee are are accepted as directives for all regulatory authorities.

3. Authorization

3.1. Licensing-registration-criteria

Under present regulations the general activity range for registration is from the exemtion levels to 10 times these values, above which sources have to be licensed, unless the sources or the instrument or equipment containing the source are constructed and certified according to special safety standards. Typical exemption levels are $5x10^3$ Bq for most alpha emitting isotopes, $5x10^6$ Bq for tritium and krypton 85 and $5x10^4$ or $5x10^5$ Bq for all other nuclides.

The Council Directive 96/29 Euratom of 13 May 1996 is laying down new Basic Safety Standards as well as exemption limits in terms of activity and activity concentration for members of the European Community. Whether registration will remain as regulatory option between exemption and licensing after the harmonization and amendment of the German regulations is not predictable at this stage.

3.2. Licensing

3.2.1. Application

While many radioisotope practices like industrial radiography or the use of isotope gauges and probes are standardized to a much simplified application procedure naming the legally responsible person, radiation safety officers, source, equipment and storage specifications, dose assessment for workers and the public, other applications require additional efforts.

Industrial irradiation facilities e.g. or tracer experiments must be justified stating the benefits weighed against any possible harm or expenses to the public.

For medical and industrial irradiators e.g. or utilization of unsealed sources design and performance specifications must be submitted such as access control, dose assessment and shielding, safety and emergency provisions, waste management and liability insurance.

3.2.2. Review and assessment of the application

Since it is the licensing authority's responsibility to determine prior to issueing any licence that the proposed practice can be sited, constructed, commissioned, operated, maintained and decommis-sioned without undue radiological risks to the personnel, the public or the environment, the authority is entitled to appoint independent expert consultants or advisory committees for any safety aspect it deems necessary on account of its own lack of specialized knowledge. Typical items are structural engineering, electronic circuitry and wiring, radiation resistance of material, fire protection and pre-vention of acts of sabotage.

3.2.3. Operation

As compared to registration licences contain a number of conditions which the licensee has to comply with. Depending on the complexity of the radiation source practice and the potential of accidental exposure of persons, the legal person responsible together with the radiation safety officer have to lay down operation manuals and radiation safety instructions for all operations both routine and emergency. The knowledge of the instructions are to be ascertained by semi-annual tutorials for all staff members involved. Licence conditions may reach from leak tests only for sealed sources up to regular contamination and dose checks, health surveillance, source accountance, consumption and emission reports, and annual inspection of components, structures and systems by a qualified consultant.

4. Inspection

Inspection is the component of the regulatory infrastructure that provides the most positive assurance that radiation safety requirements are being met, or if not, provides the opportunity to enforce corrective actions. While part of the compliance monitoring of licensees and other users of radio-nuclides is achieved by office communication, the on-site observation of operations is the most effective (and expensive) mechanism to control and enforce the safety culture of radioisotope operations.

The usually unannounced inspection is carried out according to user specific checklists. Among the following items to be checked for compliance with the licence and the regulatory authority's require-ments details are selected and prioritized according to the type of use, hazards involved, problem areas (typically clinical or medical aspects excluded):

- background information - names of radiation safety officers and responsible representatives
- details of equipment - manufacturer, identification mumbers, source activities
- records - licence, dosimetry current, area surveys, contamination, instrument tests and calibration, leakage tests, inventory of sources, audits and review of radiation safety programme, maintenance and repair work, facility modifications, health surveillance, waste disposal
- safety specifications, observations of operations - dosimeters worn and exchanged properly, personnel exposure, area and portable survey instruments, working procedures followed, source storage (shielding, warning notices, fire protection, locked/secured), protective clothing, re-spiratory protection (ventilation, fume hoods), drainage system, personnel monitoring (air sampling, bioassay), written quality assurance programme and emergency handling procedures
- safety control systems - electrical interlocks, source return to shielded position, emergency stops, access control, installed radiation monitors
- warning systems - signals, notices, designated areas (controlled/supervised)
- measurements - leakage and other representative measurements of radiation levels
- interview with personnel - knowledge of licence certificates, written procedures and warning signals, adequacy of training.

5. Dosimetry

Apart from the conventional external dosimetry, particular emphasis is laid on the control of incorporations for workers with unsealed sources of radioactivity. Various methods of internal dosimetry are applied to thorium processing industries, such as airborne activity measurements at workplaces and excretion analyses. In cooperation with other production facilities and radiological instituions in Germany investigations are under way to verify accuracy, precision and comparability of the above mentioned methods with others like exhalation measurements as well as the dosimetric and biokinetic models applied to calculate the occupational doses.

On the other hand these investigations are believed to yield some of the information on doses arising from handling and processing naturally occuring radioactive material which will be necessary to classify workplaces and take protective measures with particular respect to article 40 of the Council Directive 96/29 Euratom.

6. Conclusion

The decentralized regulatory infrastructure for radiation safety in Germany, with State Authorities and regional institutions being responsible for nearly all items of the regulatory programme, has for many years shown to be an effective and efficient system to achieve a high level of safety for the appr. 12000 users of radioisotopes. The different organization structures of the states from the one-authority-model in Bavaria to the models e.g. separating licensing and inspection authorities causes some inconveniences to "global" companies or institutions with centralized radiation protection infrastructures, but so far no safety relevant incidents or problems originated thereof.

Fundamental problems and cases of paramount significance concerning many local authorities are usually dealt with by the Federal Office for Radiation Protection or the competent Federal ministry.

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SECURITY OF HANDLING RADIOACTIVE SOURCES AND THE ROLE OF THE REGULATORY BODY IN EGYPT

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Abstract :

The motivation of the present paper was undertaken to discuss the system adopted by the National Centre For Nuclear Safety And Radiation Control (NCNSRC) in handling the radioactive sources inside the country . The system concentrates mainly on the role of the centre concerning three main categories namely regulations , licensing and training . The mutual co-operation between the regulatory body and the other agencies concerning this matter is going to be presented .

1. Introduction :

It is well know that Egypt has a variety of radiological sources . Although no nuclear power reactors have yet been , built there are two research reactors used for experimental reactor and nuclear physics research . One of them is an operating 2 MW water moderated reactor , the other one is a 22 - MW Argentinean reactor which started operation on February 1998 . The 22 MW reactor is going to be used for istope production as well as for experimental research . These reactors are located in the nuclear research centre at the Inshass site 40 Km Northeast of Cairo.

Moreover, radioisotopes are used through out the country for medical diagnosis and treatment as well as in industrial applications such as Gamma radiography . Beside that an approximately (370,000 Ci) cobalt sterilisation facility operates at the National Centre for Radiation Research and Technology in Cairo . Radioactive materials arrive regularly by plan . These radioisotopes as well as other radioactive sources are transported by different means to many places through out the country .

Egypt has a population density of about 60 millions and about 40 medical centres equipped with gamma cameras which are used for diagnostic tests on patients and about 100 laboratories use radio pharmaceuticals for invitro tests mode for the purpose of clinical diagnosis, for biological and biochemical studies . Moreover radioactive materials are used also to test and calibrate the equipment used in these facilities .

2. Role of the NCNSRC

The NCNSRC regulatory program in securing handling of radioactive sources consists mainly of following elements :

1. Regulations
2. Licensing
3. Training

3. Regulations

The adopted regulations are considered as the mile stone of the Egyptian regulatory program which define the basic requirements that must be followed by the user, registrants, and licensees .

4. Licensing

Use of radioactive source or material should be ruled through a legal person, which must apply to NCNSRC for a license . The application to get a licence should include many information which could be summarised in the following :

- The owners name , address, phone number
- The radiation protection officer, name , address , phone number
- The radioactive source material its nature, quantity half life period and the purpose of use
- The nature of the floor and working surfaces
- Engineering drawings to show the location of the buildings containing the radioactive materials and surrounding buildings and the access to this building
- The presence of ventilation fumehood, fire fighting equipment, as well as international radiation warning signs hare to be adhered to show the radiation controlled areas .
- Waste storage and disposal
- Personal dosimetry devices
- Information about worker , their names, jobs, experience and training .

Regarding the regulations adopted by the NCNSRC in controlling the safe handling of radioactive sources inside the country the NCNSRC could hang or withdraw or cancel the license in the following cases :

1. 1 In the cases of not following the measurements or precautions which the NCNSRC ask for in the cases which cause harm to environment or public security
2. 2 Introduction of any wrong information on the facility or radioactive sources or materials which are going to be licensed .
3. 3 Utilisation of ionizing radiation sources for persons not licensed for that purpose .
4. 4 Unfeasibility for the presence of reasonable resources to face any emergency cases .
5. 5 Unfeasibility of the presence of records concerning radiation exposure, unusual events , leak of sources and radioactive waste management.

5. Training

The National Centre for Nuclear Safety & Radiation Control (NCNSRC) offers two main types of training programmes for users of radiation sources . The first one is designated to graduated personnel in order to get user licensee, however the other one is for technicians and is held twice per year . This training programme includes the following syllabus :

1. Basic physics and introduction to radiation
2. Interaction ionizing radiation with matter
3. Safe transport of radioactive sources
4. Emergency planning and preparedness
5. Biological effects of radiation

In the frame of the bilateral agreement between the NCNSRC and Civil Defence a training programmes had been established for officers from different Civil Defence centers at different government rates in Egypt . The nature of this programmes contain basic information about radiation and radioactivity , biological effects of radiation, detection, protection principals etc..; in order to get them acquainted and familiar , so they could be able to help in the management of any radiological accident occurred .

6. Conclusion

One has to point out that the Egyptian regulatory body in co-operation with the civil defence organization in Egypt play very important role in securing the handling of radiation sources inside Egypt .
However one has to notify that there are some kind of shortage in development notification and registration systems inside the country .

MEDICAL MANAGEMENT OF RADIATION SAFETY AND CONTROL OF IONIZING RADIATION SOURCES IN ARMENIA

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Abstract

The events of the last 10 years, Spitak earthquake(1988) and collapse of the former USSR brought forth the changes of the political situation in Armenia and significant disorder in economy, industry, relations, including the radiation safety(RS) and control of the organization of the activities connected with the ionizing radiation sources(IRSs).

In 1989 the Armenian Nuclear Power Plant was shut down, and in 1994 it was restarted. In Armenia there are about 750 X-ray rooms, 10 radionuclide diagnostic laboratories, 20 gamma and X-ray units; 95 enterprises in industry, science and technology use the IRSs with different purposes, there are 5 electron particle accelerators of different power capacity.

About 6,000 individuals have constant contact to IRS: the roentgenologists, radiologists, the staff of NPP, accelerators, etc. Besides, more than 3,000 liquidators of the Chernobyl NPP disaster live in Armenia.

Nowadays, the precise infrastructure of RS is established in Armenia. The regulating body is the "State Atom Authority", performing the control, coordination and licensing of both enterprises and specialists. Ministry of Health, Ministry of Internal Affairs, Ministry of Ecology perform the control of IRSs' delivery into the Republic of Armenia and then their proper use and waste disposal in Armenia.

In Armenia the integration of radioactive technologies into science, engineering and medicine(for the purposes of diagnosis and therapy) began in 1960s, in parallel to the progress of the a.m. branches of the former USSR. The radiation safety(RS) monitoring and control over the works performed with the use of IRSs were exercised and centralized by the bodies of Sanitary Epidemiological Supervision on RS monitoring of the former USSR.

In 1976 the Armenian Nuclear Power Plant(WEP-440 type) was constructed. Reactor I was started up in 1976 and Reactor II - in 1980. In 1989 the NPP was shut down after the disastrous Spitak earthquake. Due to the energy crisis in Armenia it was restarted to supply power in 1994.

There are some 750 X-ray rooms, 10 radionuclide diagnostic laboratories, 20 gamma and X-ray units in Armenia; 95 enterprises of industry, science and technology use the IRSs for various purposes, there are 5 electron particle accelerators of different power capacity. However, during the past few years no radionuclide researches are carried out, the number of X-ray rooms decreased due to the critical economic situation in our country.

In Armenia about 6,000 individuals have constant contact to IRSs: roentgenologists, radiologists, the staff of NPP, the accelerators, etc. Besides, more than 3,000 residents of the Republic responded to the liquidation of Chernobyl NPP disaster and are on a register for prophylactic medical follow-up in Republican Research Center for Radiation Medicine and Burns(RRCRM&B). The infrastructure of RS is created in Armenia. The regulation body in this concern is the "State Atom Authority" supervising the execution, coordination and licensing the enterprises and specialists.

Much attention is devoted to radiation safety at NPP, performed by self dependent department of RS immediately at the NPP.

Much prominence in ensuring the RS belongs to Ministry of Health, the regulating control is provided by its Department of Hygiene and Epidemiological Supervision in concern of radiation situation and licensing of specialists in the system of Public Health. The safety of IRSs at the enterprises, their transportation and wastes disposal, permissions for the receipt, storage and rights to perform activity are conferred and controlled jointly with Ministry of Internal Affairs. All the dosimetric and radiometric researches are carried out by the department of RS of the Center.

Both the Environmental Control and Monitoring of radiation background are performed by the appropriate subdivision in the structure of Ministry of Ecology and Hydrometeorology.
The management of medical assistance in a case of radiation emergencies is carried out by RRCRM&B.

Nowadays, as a WHO Collaborating Center, RRCRM&B performs the following activities:

1. serves as a basic/focal point for medical care in cases of human radiation injuries;
2. carries out training of specialized staff in radiation medicine, radiation hygiene and radiobiology;
3. performs the development and planning of all the measures on medical assistance in the event of radiation accidents;
4. coordinates researches on radiation medicine and radiobiology;
5. develops plans and normative relevant documentation.

In case of an accident the RRCRM&B is prepared to:

- promote the team for on-site aid to the emergency victims;
- promote the dosimeter control group to study the radiation/contamination of the area;
- perform the arrangement ("assortment") and transportation of those injured(radiation/ contamination accident victims;
- carry out the diagnosis and treatment:
  a)by means of biodosimetry(bioassay),
  b)by means of radiometry with the use of whole body counter;
- render specialized medical aid to wounded and injured persons.

The RRCRM&B functions as a Republican Center on diagnostics and treatment of general and local/ topical radiation injuries, RS and population protection. The RRCRM&B is constantly preoccupied by elaboration and improvement of methods of prophylaxis, diagnostics and therapy of radiation injuries, bioindication. Great importance is given to the study of low radiation levels.
Taking into account all the a.m., in 1995 the Department of burns was created at the RRCRM&B, functioning now as a Republican Center of Burns(RCB). It would promote assistance in a case of a radiation accident. Now the RCB admits patients not only from all the districts of Armenia, but from other countries of the region as well.
Nowadays, a number of Projects are performed at the RRCRM&B with the assistance of IAEA on RS, radiation medicine and Training Programmes.

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SAFETY AND SECURITY OF RADIATION SOURCES AND RADIOACTIVE MATERIALS: A CASE OF ZAMBIA -LEAST DEVELOPED COUNTRY

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Abstract

In Zambia, which is current (1998) classified as a Least Developed Country has applications of nuclear science and technology that cover the medical, industrial, education and research. However, the application is mainly in medical and industry. Through the responsibility of radiation source is within the mandate of the Radiation Protection Board. The aspects involving security fall on different stakeholders some that have no technical knowledge on what radiation is about. The stakeholders in this category include customs clearing and forwarding agents, state security/defence agencies and the operators. Such a situation demands a national system that should be instituted to meet the safety and security requirements but takes into account the involvement of the diverse stakeholders. In addition such system should avoid unnecessary exposure, ensure safety of radioactive materials and sources, detect illicit trade and maintain integrity of such materials or sources.

This paper will provide the status on issue in Zambia and the challenges that exist to ensure further development in application of Nuclear Science and Technology (S & T) in the country takes into account the safety and security requirements that avoid deliberate and accidental loss of radiation sources and radioactive materials. The Government has a responsibility to ensure that effective system is established and operated to protect radiation sources and radioactive materials from theft, sabotage and ensure safety.

1.0. Introduction

In the pursuit of peaceful application of nuclear science and technology to address pressing national developmental needs, the aspects of safety and security of radiation sources and radioactive materials become a reality. This situation provide a demanding responsibility to the nation in particular if it is classified developing or least developed.

In Zambia, which is a Least Developed Country (LDC) application of nuclear science and technology is in medical, industrial, education and research covering 136 institutions. The radiation sources used include Cobalt-60 irradiator, gamma camera, CT Scan, radiological equipment and NDT (aviation and mining) equipment.

The responsibility of safety of radiation sources is a responsibility of the Radiation Protection Board. However, the aspects relating security has a different dimension in the sense that it covers various stakeholders such as immigration, manufacturer, clearing agents, security, agencies and operators and the different roles they have to play towards achieving the objective. In addition, currently no legislation exist on security of the radiation source and radioactive materials except what is done through the mandates of the various stakeholders and the international organization agreements such as safety convention, IATA regulations, etc.

2.0. Country situation

The Radiation Protection Board Licenses various users of ionizing radiation and undertakes personnel dosimetry of all radiation workers in the country covering 136 institutions in various sectors (1). The RPS has limited technical staff and expertise.

The primary uses of ionization radiation in Zambia are industry (radioisotopes gauges and non-destructive testing), diagnostic medicine (x-ray radiography, CT scan and nuclear medicine, agriculture (Geiger Muller counter trace studies and moisture measurements) and research (cobalt-60 and caseium-137 irradiators for medical raw material and products sterilisation, food preservation and induced mutation) (2).

The imports of ionizing radiation equipment in the country was through a mining companies, airline (NDT) and medical hospitals. After Zambia joining the IAEA in 1969, promotion of nuclear S & T to meet the development needs in agriculture and industry resulted in imports that include cobalt-60 and caesium-137 sources.

Although the Ionizing Radiation in Zambia was enacted into law in 1972. The control of the imports started in the mid 1980's when subsidiary legal instruments were instituted which has resulted in the licenses for operators, transporters, waste management and disposal. In the period, 1985-1995 the RPS has issued Licenses for various ionizing radiation uses. National Inventory of radioactive sources and materials is being compiled.

Safety and security of radioactive material is assured if the air transportation is used since, IATA regulations are employed. In technical assistance programmes the regulations and conventions of international organizations such as IAEA (BSS, Conventions on Safety and Physical Protection of Nuclear Materials and Facilities) assist to strengthen the local safety situation through implementation of various measures.

The major weakness in safety and security arise from lack of knowledge by non-technical personnel from agencies such as Zambia Revenue Authority (Customs), forwarding and clearing agencies, security/defence agencies and the public. Insecurity of radioactive material and sources come from road transportation in particular in borders where natural barrier is absent. The inspection at such borders may be lax especially that road transport regulations may not strictly be adhered to as is the case with air transport. To underscore this aspect, the Zambia Police, Drug Enforcement Commission with help of the RPS have in the last five years confiscated five (5) spent sources were brought in the country illegally through a land border. There is currently no system to detect illicit activities.

A risk exists of scrap metal dealers getting devices containing sources with idea of melting for production of metallic products and the airport/border personnel not taking into account the safety and security of radioactive materials and sources.

Sensitization Workshop by the RPS have gone some was in providing relevant information to various personnel at the airport and other interested organizations. Workshop by environmental protection of civil pressure groups such as Waste Management Association of Zambia held in conjunction with RPS, and the National Council for Scientific Research has also assisted to sensitize the public, policy makers and stakeholders. Setting up of an interim storage facility by the mining company has provided a step to improved security and safety of spent sources. The inventory for 1997 for a copper mining conglomerate indicate 40 sources in use, 28 not in use and 178 in storage.

3.0. Critical factors for safety and security

The factors that are critical to safety and security of materials and radioactive sources include:-

(i) ***National Infrastructure*** - This consists of physical infrastructure, legal framework, technical capacity and mechanisms for notification of irregulatory, check compliance and undertake intervention.

(ii) ***Financial*** - Assured funding to enable existence of the national infrastructure lead to improved safety and security and effective operations of relevant organs.

(iii) ***Education and Information*** - Information should be available for stakeholders and public to enable them understand and do things that minimise or eliminate safety and security. Incidents of accident exposure in a number of countries worldwide emanate from lack of information.

The technical personnel should have the information relating to safety standards, practices and management.

(iv) ***Globalisation*** - with its merit of economic growth has brought new demands on the security and safety of material that cross borders in particular those that do not have technical and financial resources to detect violation and illicit activities.

4.0. Ways to enhancing safety and security

There are several ways/methods that can be employed to enhance the safety and security.

4.1. Access to appropriate information - The operators, public and the regulatory authority should have access to appropriate information that will ensure that factors that may undermine the safety and security are not compromised. Security Officers and other stakeholders should be aware of existence practices and institutions that can assist them to address the problem.

4.2. Adherence to standards - The standards for handling and managing radioactive materials and sources and waste arising thereof should be adhered to.

4.3. Technical capacity for detection of violation and verify compliance
- The nation should have the personnel and equipment to detect and verify violation of safety and security requirements.

4.4. Limitation in access (Restriction) or exclusion - Limiting access to places where radioactive materials and sources are found can reduce the danger to the public. Methods employed to control should depend on the nature and the classification of the radioactive material and sources. Physical security to such places is also held an important deterant to illicit activities.

4.5. Consultative mechanisms - There should be consultative mechanisms of the various stakeholders. The challenge is whether this should be formal or loose alliance. Whichever option is taken the Government through an appropriate agency needs to take leading role (4).

4.6. Mechanism Control, Record Use and Abandonment - A mechanism should exist to record (inventory) and control import, use, audit and manage the radioactive materials and sources when expired, not in use and when abandoned.

5.0. Way forward

In the context of Zambia, the way forward is summarised by the following actions:-

5.1. The Radiation Protection Board in collaboration with the various stakeholders forming a lose alliance to determine the areas of strength and weakness and agree to the remedial measures to be implemented.

5.2. Education and sensitisation of the stakeholders and public on measures that may lead to undermining of radioactive material safety and security.

5.3. Encourage adherence to relevant regulations and standards during manufacture, importation, use and disposal. Lapse at any of the stages spells disaster for the country.
5.4. Work towards well-funded and effective technical and administrative structure that can detect and ensure compliance of radioactive material and sources.
5.5. Co-operating with international organizations that have interest in radiation safety and security such as International Atomic Energy Agency (IAEA), World Health Organization (WHO) and International Police (INTERPOL). International agreements and guidelines can assist the country take necessary measures to improve safety and security.
5.6. Acquisition of technical capacity to detect of violation and check Compliance.

6.0. Conclusion

This paper has highlighted the issues that need to be considered when a Least Developed Country like Zambia makes the deliberate efforts to establish a system to ensure safety and security of radioactive materials. The conclusion is that the Government has responsibility to ensure that an effective system is established and operated to protect radiation sources and radioactive materials from thefts, sabotage and loss and also ensure safety. Lastly, education and information of the public and stakeholders can assist to significantly reduce on hazards that may arise if this aspect was not done. An informed public is key to safe and secure environment. An informed public in a way force providers of specific services to adhere to prescribed standards and practices.

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DISPOSITIONS REGLEMENTAIRES ET TECHNIQUES APPLICABLES AUX INSTALLATIONS METTANT EN OEUVRE DES RAYONNEMENTS IONISANTS

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Resume

L'Office de Protection contre les rayonnements ionisants, établissement public de l'Etat, placé sous la tutelle des Ministères chargés de la Santé et du Travail a parmi ses différentes missions celle de vérifier le respect effectif des règles de radioprotection destinées à assurer la sécurité des intervenants et du public dans les installations mettant en oeuvre des rayonnements ionisants.

Ces règles concernent autant la compétence des utilisateurs, notamment dans le domaine médical où l'emploi des rayonnements ionisants sur l'homme est réservé aux seuls médecins (ou aux dentistes pour l'art dentaire), que la conception des installations en fixant des contraintes techniques pour leur réalisation puis pour leur exploitation. Elles précisent également les conditions dans lesquelles seront réalisés les contrôles permettant de vérifier le respect effectif des mesures applicables en matière de radioprotection.

1. Rappel des dispositions reglementaires applicables aux installations mettant en oeuvre des rayonnements ionisants

DOMAINE MEDICAL

Ces dispositions reposent essentiellement sur le régime d'agrément des installations médicales de rayonnements ionisants, institué par l'arrêté du 23 avril 1969 modifié, qui conditionne le remboursement par les Caisses d'Assurance Maladie des actes qui y sont effectués. L'agrément n'est accordé qu'aux installations dotées d'une infrastructure suffisante pour permettre le respect des règles de radioprotection.

Les agréments sont accordés pour une période maximale de 10 ans renouvelable, dans la limite de 25 ans d'âge des appareils. Le régime d'agrément à notamment permis la suppression progressive des installations de radioscopie simple technique en voie d'extinction définitive.

Dans le cas de la mise en oeuvre de radioéléments artificiels en sources scellées ou non, leur détention et leur utilisation sont soumises, à autorisation préalable du Ministre de la Santé, après avis de la Commission Interministérielle des Radioéléments Artificiels (CIREA), cette procédure étant articulée avec celle de l'agrément.

Ces procédures peuvent être précédées par celle relative aux équipements matériels lourds fondée sur une carte sanitaire et des indices de besoins pour certains types d'appareils (accélérateurs de particules, appareils de télégammathérapie, scanners, gamma caméras...). Le tableau 1 présente l'articulation des différentes procédures.

TABLEAU I - Articulation des différentes procédures (domaine médical)

	Autorisation équipement matériel lourd	Autorisation radioélément artificiel	Agrément
Radiodiagnostic	NON	NON	OUI
Scanographie	OUI	NON	OUI
Accélérateur	OUI	NON	OUI
Télégammathérapie	OUI	OUI	OUI
Curiethérapie	NON	OUI	OUI
Médecine nucléaire	OUI	OUI	OUI

DOMAINE NON MEDICAL

Il s'agit pour l'essentiel d'installations du milieu industriel ou de celui de la recherche scientifique non biomédicale.

Comme dans le domaine médical, s'il y a mise en oeuvre de radioéléments artificiels en sources scellées ou non, leur détention et leur utilisation sont soumises également à autorisation préalable. Cette autorisation est délivrée dans ce cas par le Président de la CIREA.

Cette procédure d'autorisation est le plus souvent complétée mais jamais remplacée par celle des Installations Classées pour la Protection de l'Environnement (ICPE) dont la maîtrise d'oeuvre est assurée par le Ministère de l'Environnement. En fonction du niveau d'activité des radioéléments d'origine naturelle ou artificielle détenus et utilisés les établissements assujettis sont soumis à une procédure soit de déclaration auprès de la Préfecture de leur département soit d'autorisation préfectorale.

Si l'établissement détient des générateurs électriques de rayonnements ionisants ou des substances radioactives naturelles, il est tenu d'en faire la déclaration notamment auprès de l'OPRI, en application du Décret du 2 octobre 1986, relatif à la protection des travailleurs contre les dangers des rayonnements ionisants. Le tableau 2 présente l'articulation des différentes procédures.

TABLEAU II - Articulation des différentes procédures (domaine non médical)

	Autorisation CIREA	I C P E	Déclaration
Radioéléments artificiels sources scellées ou non	OUI	OUI *	NON
Radioéléments naturels	NON	OUI *	OUI
Générateurs électriques	NON	NON	OUI

* : exemption, déclaration ou autorisation en fonction des niveaux d'activité des radioéléments détenus et utilisés.

2. Conception des installations - cas des installations medicales

a) INSTALLATIONS DE RADIOLOGIE

Ces installations dont plus de 55000 sont en fonctionnement en France doivent être réalisées conformément à la norme applicable :
NFC 15-161 pour les installations de radiologie médicale,
NFC 15-163 pour les installations de radiologie dentaire.

Ces normes imposent notamment des obligations en matière de surface, de protection et de signalisation des locaux recevant les installations.

L'installation doit être réalisée par un installateur enregistré à l'OPRI qui doit établir le certificat de conformité à la norme applicable. Ce certificat engage ainsi sa responsabilité au regard de la procédure d'agrément

En vue de leur agrément, les installations doivent en outre être équipées d'un générateur datant de moins de 25 ans porteur, pour les matériels neufs, du marquage CE objectivé par un certificat établi par le constructeur ou son représentant en France ou pour les appareils d'occasion conforme à un type homologué selon la norme NFC 74-100.

Il appartient donc à l'établissement d'obtenir puis de conserver soigneusement les certificats de conformité du générateur et de l'installation dont la production est indispensable pour l'agrément des installations et dont la présentation est exigible lors des contrôles.

b) INSTALLATIONS DE RADIOTHERAPIE EXTERNE

Il s'agit dans ce cas des appareils de télégammathérapie équipés d'une source radioactive de Cobalt 60 et des accélérateurs de particules dont le parc se compose en France respectivement de 105 et 266 machines.

La protection des locaux, en particulier la salle de traitement, doit être déterminée de façon à respecter autour de ceux-ci les limites annuelles d'exposition des travailleurs et/ou du public. Une étude spécifique pour chaque installation doit être réalisée par le fournisseur de la machine en liaison avec le radiophysicien de l'établissement dans lequel elle doit être implantée. Cette étude, soumise à l'approbation de l'OPRI, permet de définir les épaisseurs et la nature des différentes protections à prévoir. En outre, l'installation doit être équipée de différents systèmes de sécurité tels que :

- Signalisation lumineuse d'émission du faisceau à l'extérieur et dans la salle ainsi que, le cas échéant, dans certains locaux annexes.
- Système de surveillance vidéo, à partir du poste de commande, de la salle de traitement.
- Interphone.
- Arrêts d'urgence type coup de poing coupant le faisceau de rayonnement.
- Sécurité coupant l'émission du faisceau en cas d'ouverture de la porte de la salle d'irradiation.

Il convient d'apporter une attention toute particulière à la qualité et aux caractéristiques du béton employé pour la réalisation des parois de la salle d'irradiation afin qu'il soit effectivement conforme aux critères (nature, densité...) définis lors de l'étude préliminaire. Le respect de ces critères contribue de façon déterminante à la radioprotection de l'installation.

c) INSTALLATIONS DE CURIETHERAPIE

Ces installations au nombre de 118 se répartissent entre les unités destinées à la curiethérapie à bas débit (sources de faible activité de Césium 137 ou Iridium 192 mises en place sur le patient durant plusieurs jours dans ou au contact de la tumeur à traiter) et celles réservées à la curiethérapie à haut débit (source d'Iridium 192 de forte activité -370 GBq- séjournant un temps très bref dans ou au contact de la tumeur). Dans le premier cas, les patients sont hospitalisés au sein d'unités spécialisées dans des chambres individuelles protégées dont les parois sont renforcées complétées par des locaux spécifiques pour le stockage et la préparation des sources. Dans le second cas, le traitement se déroule dans une salle d'irradiation comparable à celle utilisée en radiothérapie externe.

d) MEDECINE NUCLEAIRE

Les règles d'aménagement de ces installations, dont 276 sont en fonctionnement en France ont notamment pour but de limiter les risques de contaminations radioactives et de leur extension. Dans ce but, des contraintes ont été imposées concernant :

- La distribution des locaux (regroupement des zones de manipulations radioactives)
- Leur aménagement intérieur (revêtements des sols, des murs et des surfaces de travail lisses, imperméables, sans joint et facilement décontaminable) et leur équipement (enceinte blindée pour la manipulation des sources, stockeurs, poubelles spécifiques, matériels portatifs de radioprotection...).
- Les systèmes de ventilation (mise en dépression des locaux, taux de renouvellements horaires de l'air au moins égal à 5, rejet de l'air extrait sans risque de recyclage...).
- Les dispositifs de collecte et de stockage des déchets solides (local de stockage, fûts et containers...) et des effluents liquides (canalisation distinctes pour les effluents actifs, cuves tampons...)

Ces différentes dispositions constructives sont indispensables pour assurer une bonne radioprotection dans ces installations. Elles ne seraient pas suffisantes si elles n'étaient complétées par l'élaboration de consignes de sécurité propres à chaque installation et la mise en place d'une surveillance médicale spécifique du personnel exposé. Le respect effectif de tous ces éléments au cours du temps doit être régulièrement vérifié à l'occasion de programmes de contrôles.

3. Dispositions concernant les controles des installations - cas du domaine medical

L'agrément n'étant accordé qu'aux installations comportant une infrastructure technique suffisante pour permettre le respect des règles de radioprotection, il est donc nécessaire de procéder à des contrôles avant mise en service puis périodiquement des installations pour s'assurer du respect effectif de ces règles. Ces vérifications s'articulent de façon étroite avec celles qui sont prévues au titre de la protection des personnels de catégorie A au sens du décret n° 86-1103 du 2 octobre 1986.

Compte tenu des dispositions réglementaires en vigueur, trois types d'intervenants sont susceptibles de procéder à ces contrôles : la personne compétente en radioprotection désignée et mandatée par l'employeur après autorisation de l'Inspecteur du Travail, l'Office de Protection contre les Rayonnements Ionisants et les organismes habilités par arrêté des Ministres chargés du travail, de la santé et de l'agriculture puis désignés spécifiquement par l'OPRI pour certains types de contrôle. C'est ainsi que la compétence de ces organismes est actuellement limité aux contrôles des générateurs électriques utilisés pour le radiodiagnostic.

SOURCES SCELLEES ET GENERATEURS ELECTRIQUES

a) Un contrôle avant la première mise en service de la source ou du générateur.

b) Un contrôle après toute modification apportée aux modalités d'utilisation, à l'équipement, aux dispositifs de sécurité et au blindage.

c) Un contrôle après tout cas de dépassement des limites d'exposition.

d) Un contrôle périodique des sources, des générateurs et de leurs installations, dont la périodicité est fixée par l'arrêté du 2 octobre 1990 :

- à trois ou deux ans pour les générateurs et leurs dispositifs de protection selon que leur date de mise en service est inférieure ou supérieure à dix ans
- à un an pour les sources scellées et leurs installations.

e) Un contrôle d'ambiance effectué au moins une fois tous les six mois en zone surveillée.

f) Un contrôle d'étanchéité des sources scellées.

g) Un contrôle après mise en demeure de l'Inspecteur du Travail.

SOURCES NON SCELLEES

a) Un contrôle initial avant la première mise en service des installations ou locaux où les sources non scellées seront utilisées.

b) Un contrôle ultérieur (et permanent) de ces installations et locaux.

c) Un contrôle des moyens d'évacuation des effluents et des déchets radioactifs.

d) Un contrôle après tout cas de dépassement des limites d'exposition.

e) Un contrôle d'ambiance effectué au moins tous les six mois en zone surveillée.

f) Un contrôle terminal des installations et des locaux en cas de cessation définitive d'emploi.

g) Un contrôle après mise en demeure éventuelle de l'Inspecteur du Travail.

Ces dispositions sont transposables au domaine non médical où les organismes agréés par le Ministère du Travail sont chargés d'effectuer les contrôles en complément de ceux dévolus à la personne compétente en radioprotection. L'OPRI intervient dans ce cas, à la demande de l'Inspection du Travail.

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PERFORMANCE AS A BASIC REGULATORY RULE

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Abstract

In Argentina, the Nuclear Regulatory Authority has been sustained, from beginning by a normative system whose fundamental features are its requirements for performance.

The Authority has defined indicators for carrying out the classification of practices as major o minor. (As a function of the complexity of processes and operation, equipment, associate risks and type of consequences, etc.).

An example is given base on the requirements of standards related with the practice of gammagraphy in Argentina.

From the Authority records we know that the effective dose of operators registered do not exceed 5 mSv per year. The associate risk is lower than $2\ 10^{-4}$ *per year.*

Risk assessment in scenarios resulting in a potential exposure, taken into account the Argentine standards gives a total risk per year in the order of 10^{-4} *for workers and* $4\ 10^{-5}$ *for members of the public.*

The contents and requirements of system that sustains the regulatory authority can be prescriptive or just based in performance. A decision in favour of one of them should not only reflect the technical-scientific reality of the country implementing it but also other factors like social and economic issues.

1. Introduction

Any system enacted to control exposure to ionising radiation has as primary objective the protection of health of people against the deleterious effects of radiation.

Establishing the appropriate level of radiological protection and safety of radiation sources used in practice or intervention attains this objective. In other words, by standards that guarantees appropriate levels of risk and insuring compliance, while performing the practice or in accidental situations.

Obviously implementing the philosophy, principles, and objectives of a regulatory system is not an easy task. When is carried out a decision has to be taken how detailed should be regulations to be enforced.

The contents and requirements of a normative system that sustains the regulatory authority can be prescriptive or just asking for performance objectives. The decision in favour of one of them will not only reflect the technical-scientific reality of the country implementing it but also other factors like social and economic issues.

Important points to keep in mind while establishing the framework of the regulatory system are:

- the qualifications and
- how clearly are functions and responsibilities of regulators and registrants defined.

The importance of these characteristics facilitates the implementation and the daily control of compliance of standards and rules established by the regulatory system.

More clarity in establishing functions, responsibilities, and training requirements simpler would be to implement the infrastructure and control mechanisms of a regulatory system based essentially on a performance normative. A system implemented this way allows the responsible of the practice to act with freedom but within well defined limits.

Consequently, carrying out regulatory tasks penalises less the practices and is possible to direct more effectively the Authority resources towards the weakest points in the regulatory system.

On the contrary, if there are difficulties to implement a regulatory framework on the above-mentioned points, the initial setting of the system could be based on prescriptive standards. In such system, a practice should be authorised fixing all parameters in order to assure normal operation restraining the potential exposure's risk.

Nevertheless, since times degrades operating conditions and components alike and consequently increases probability of abnormal events, the only coherent barrier to degradation is:

- an increment in a clear definition of functions and responsibilities and
- enormous efforts towards, a permanent requalification of regulators and registrants.

A detailed system can generate a special risk from just compliance with regulations without leaving margin or will for improvements or interpretations of new „forms of non-safety" learnt during practice. Such systems generally are very extensive and must be updated when technology changes. In particular, retraining allows, learning from experience, to improve technical infrastructure and the safety culture in the practices.

An example is given that supports the preceding statements, on the base of analysis of some requirements of relevant standards related with the practice of gammagraphy in Argentina. [1][2][3]

2. An outline of the argentine regulatory system

In Argentina, the Nuclear Regulatory Authority sustains, from beginning on a normative system whose fundamental and dominant feature is its requirement of performance. A program of permanent training always accompanied its development and consolidation.

The Regulatory Authority has defined clearly the objectives of radiological protection and safety of sources that should be attained, together with functions and responsibilities of the parties. Also has fixed minimum qualification training, required to receive the authorisation to work with radioactive material or ionising radiation. Besides the control mechanisms established includes the need of permanent training, in order to maintain or to improve safety level.

Above the exemption level, is only possible to carry on a practice if the Regulatory Authority grants a License for a major or an Authorisation for a minor practice. The Regulatory Authority has defined indicators for carrying out the classification of practices (as a function of the complexity of processes and operation, equipment, associate risks and type of consequences, etc.). Consequently has defined as major practice every type of nuclear reactor (including zero power), radioactive installations or major accelerator and as minor practice all installation or practice not exempt that have not been qualified as major.

One indicator is the denominated Radioactive Inventory Index, $r = \sum_i a_i A_i$; where A_i is the activity of all radionuclides present simultaneously in a practice. The parameter a_i, for the case of gammagraphy, is obtained calculating the value from the dose rate at 1 meter given by the radionuclide i, divided by 0.1 Sv/h. If $r< 2$ the practice is defined as a minor and if $r >2$ a major.

Considering the activity of sources used in gammagraphy the practice should be declared as major. However, it has been defined as a minor practice, with a level of requirements superior to the average minor practice. (An application of the performance philosophy based on a defined safety goal).

This decision was based essentially in:

a) that equipment used are very similar,
b) the procedures and operation are simple and repetitive,
c) It is possible to limit up to reasonable values the level of risk to potential exposures.

Still, even after the regulatory framework for the practice has been defined, the user has the possibility (and the responsibility) facing a particular situation, of carrying out an analysis of optimisation of the operation with the purpose of evaluating and justify possible changes.

This „freedom“ has its clear limits. One condition is to consider permanently parameters allowing the evaluation of event precursors leading to potential exposures. (e.g. inspection, and maintenance of the equipment, exposure rates during the operation, etc.).

As example the normative determines the use of an exclusion area (but it doesn't gives dose rates values at the border), when the practice is carried out in open space, like the case of taking x-rays in structures very near to highways and bridges. Complying with the standard "blindly" transit should be stopped.

However, sometimes such decision could create a conflict with the community. The Argentine standard allows the practice responsible to bypass its requirement.

In that case, the integrated effective dose E that the most exposed individual member of the public would receive during the time spent at the place of the practice while transit is passing through would be:

$$E = \Gamma_0 \pi d_0 / v.$$

Being Γ_0 the dose rate (about 50 mSv/h) at a fixed distance d_0 (of the order of 3 m) and v, the speed of vehicle. A conservative calculation, without considering collimation effects, gives as estimate a value of 6 μSv for E and a collective dose S, of the order of 10 man mSv per x-ray. These values are acceptable in relation to cost and the economic and social burden due to interruption of vehicle circulation.

One has to bear in mind that carrying on the practice in such manner is not the usual one the only dose will be from external irradiation. Moreover is very unlikely the same individual member of the public would be exposed in more than one occasion.

On the other hand, the important to keep in mind among the scenarios chosen with risk's evaluation purpose, would be the possibility of a bottleneck creating a traffic jam or a crash at the practice location. Such situation can be overcome by withdrawal of the source into its shielded container.

3. Risk assessment of a "minor" practice: gammagraphy

Compliance with the Nuclear Regulatory Authority standards while carrying on the practice ensures an appropriate radiological protection and safety level for normal operation and a limited risk for potential exposure.

From the Regulatory Authority records we know that the effective dose of operators registered and informed per calendar year do not exceed 5 mSv. Consequently can be assured that the normal practice have an associate risk lower than $2\ 10^{-4}$ per year.[4] [5]

The risk evaluation for potential exposure has been made using event tree analyses. It is not an easy job because use of mobile sources is mostly based on good operational procedures. Therefore quantitative analysis of potential exposures from such sources is more difficult and there is more room for uncertainties than in the analyses of fixed installations with designed intrinsic safety features. [6]

This does not only hinder the task to select the appropriate set of probability numbers for every node but also for dose assessment as result of the sequences. The values used for the probabilities were worked out from operating experience and experts' opinion.

The doses associated with sequences producing potential dose only to workers, were the better quantified. On the other hand, there is more uncertainty in quantification of sequences that conclude with a potential exposure to members of the public. In a conservative approach, deterministic harm was assumed (f (E)= 1) for most of them.

Among all the possible scenarios involving mobile sources have been analysed those considered important due to their contribution to total risk such as source lost due to operational mishap or error, [i.e.]. Source disconnection or cable jamming. [6]

The result of the evaluation has been taken as representative for five possible scenarios with sequences that could conclude in potential exposure to workers and to members of the public. Obviously, the calculated risk is only relevant to mobile sources within the regulatory system.[6][7]

The risk assessment in previously mentioned scenarios with event sequences resulting in a potential exposure, taken into account the relevant Argentine standards requirements gives a total risk per year in the order of 10^{-4} for workers and 4 10^{-5} for members of the public. The total risk per year for workers calculated, is of the same order than the normal operation risk. For the members of the public, the value of total risk is larger than the regulatory defined risk for this practice (1.5 10^{-5} in one year) but acceptable if uncertainties are taken into account.

It has to be underlined that for source losses especially due to road accidents or robbery, the Argentine Nuclear Regulatory Authority has organised a Radiological Emergencies Intervention Group in collaboration with different security forces. Intervention is triggered by the report of occurrence of an abnormal situation and acts in the mitigation of the consequences and only after, the practice responsible capability has been overcome.

4. Conclusions

It is possible to sustain a regulatory system on a normative based in performance when the functions and responsibilities are well defined and importance is given to training. It allows more freedom and gives chances to improve the radiological safety, inside a controlled framework.

We strongly believe that even when regulatory systems are implemented initially with a strongly prescriptive regulation, it is necessary to carry out all efforts needed to facilitate the change towards a normative where performance is the basic rule.

5. References

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A PROPOSAL FOR AN INTERNATIONAL CONVENTION ON RADIATION SAFETY

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Abstract

One century has passed since harmful effects of radiation on living tissues were recognized. Organized efforts to reduce radiation hazards began in early 1920s. Major efforts by the ICRP since 1928, aided by ICRU, greatly helped in formulating principles, policies and guidance for radiation protection. The WHO formally recognized ICRP in 1956 and began implementing ICRP recommendations and guidance throughout the world. The IAEA, after it took office in 1957, began to establish or adopt standards of safety based on ICRP recommendations and provide for application of these standards in the field of atomic energy. Later on, other pertinent international organizations joined IAEA in establishing the Basic Safety Standards on radiation safety. The IAEA has issued, until now, nearly couple of hundred safety related documents on radiation safety and waste management. However, in spite of all such international efforts for three quarter of a century, there has been no effective universal control in radiation safety. Problems exist at the user, national, international and manufacturers and suppliers levels. Other problems are management of spent sources and smuggling of sources across international borders. Although, radiation and radionuclides are used by all countries of the world, regulatory and technical control measures in many countries are either lacking or inadequate The recommendations and technical guidance provided by the international organizations are only advisory and carry no mandatory force to oblige countries to apply them. Member States approve IAEA safety standards and guides at the technical meetings and General Conference, but many of them do not apply these. An International Convention is, therefore, essential to establish international instrument to ensure universal application of radiation safety.

1. Why an international Convention is needed?

Soon after the discovery of X-rays by Roentgen in 1895 and radioactivity by Becqurel in 1896, X-rays and gamma rays began to be used in medicine. The use of sealed sources in medicine may be traced as far back as 1901. Other applications of radiation sources in various fields continued to grow with time. Today, X-ray machines and radionuclides in sealed and unsealed forms are widely used all over the world for various purposes, including consumer products.

Since the very beginning of its use in medicine about one hundred years ago, radiation was recognized as a health hazard. However, no organized efforts to study the health effects and reduce the hazards were made until early 1920s. The International Congress of Radiology established the International Commission on Radiation Units and Measurements (ICRU) in 1925 and the International Commission on Radiological Protection (ICRP) in 1928. Over the past 70 years, ICRP, aided by the efforts of ICRU, developed standards and recommendations for protection of occupational workers and the members of the general public. The International Atomic Energy Agency (IAEA), after it took office in 1957, began to develop radiation safety standards and guidance based on the ICRP recommendations. From 1960 onwards, the IAEA, with the assistance of, or joint collaboration with other international organizations, where appropriate, continued to issue safety standards, codes and guides in the areas of radiation protection and radioactive waste management. The current Basic Safety Standards for Radiation Protection and for the Safety of Radiation Sources (1) was jointly prepared by the IAEA,WHO, ILO, NEA/OECD, FAO and PAHO.

In spite of all such efforts by the international organizations, as well as by many national organizations, effective universal application of the radiation safety standards and guides has not been achieved. Many countries around the world still lack in national regulatory and technical infrastructures in radiation safety. In addition, there are many countries which are using radiation sources but are not Members of United Nations or UN Specialized Agencies like the IAEA.

It is evident that preparation of safety standards and guides is not the end point; an international instrument is essential to ensure that countries using radiation sources apply such standards and technical measures of radiation safety. Such an international instrument can be established only through an

International Convention. An international Convention on Radiation Safety should have been established long time ago.

2. What are the problems encountered?

2.1. Variety and number of radiation sources

Nearly one million diagnostic X-ray units are in use all over the world Therapeutic X-ray units are not as many, but still numerous. The following Table lists sources of other types in use The data is as of 1993, but still depicts the extent of use of radiation sources

Source	Number	Average Source Strength
Teletherapy units	3000	Co-60 - 220 TBq, Cs-137 - 40 TBq
Brachytherapy units	120 000	20 MBq - 4 GBq
Radiography units	50 000	Ir-192 - 4 - 11 TBq, Co-60 - 1.5 TBq
Commercial irradiators	about 120	Co-60 - 40 000 TBq, Cs-137 - 400 000 TBq
Industrial gauges	500 000	--
Medical electron accelerator	Over 600	Usual energy range - 5 - 25 MeV

2.2. Problems at the user level

At the user level, the problems seem to derive from inadequate education and training , and disregard for, and often violation of, radiation protection standards and procedures. Large radiation facilities, in general, have radiation protection specialists and radiation protection services, but small facilities do not. Small users are specialists in their own fields, but they are not usually adequately trained in radiation safety Many radiation accidents occurred due to one cause or the other Fatal accidents with radiation sources occurred in Italy in 1975 (2), Norway in 1982 (3), Mexico in 1983 (4), Brazil in 1987 (5), El Salvador in 1989 (6), Israel in 1990 (7), France in 1991 (8) and Byelorussia in 1991 (9). Accidents from minor to medium scales led to radiation injuries; some are reported but others are not. According to Lushbaugh et al (10), 296 accidents occurred with sealed sources up to 1988 in which 25 000 people received overexposure, leading to 69 deaths The majority of the accidents occurred due to malfunction of source manipulating devices, inadequate maintenance, human error or violation of safety procedures.

2.3. Problems at the national level

At the national level radiation sources, either radiation generating machines or radionuclide sources, are not usually procured through one single authority. Countries which do not have national infrastructure for radiation safety lack in mechanisms for licensing and registration of sources. Governmental bodies exercise their own authorities and there are no centralized controls in many countries. Also, jealousy in exercising authority and lack of co-operation are often noted among various government bodies involved.

National authorities in many developing countries, except the national atomic energy orgnization, or in some cases, health authorities, do not have radiation protection services. In more than 60 Member States reviewed by the IAEA Radiation Protection Advisory Team (RAPAT) revealed that nearly 40 Member States do not have national radiation safety legislation and about 50 Member States have inadequate radiation monitoring infrastructures.

2.4. Problems at international level

Counterpart government bodies in the Member States are different for different United Nations specialized agencies For example, WHO operates through the Ministry of Health, ILO through the Ministry of Labour, IAEA through the Atomic Energy organizations, and so on. Also, the number of Member states of different UN specialized agencies are different. This makes it difficult and unmanageable to transmit messages on radiation safety The IAEA, being the only international organization in the United Nations charged with the mandate on nuclear and radiation safety, should have a clear, definite and effective role to play to ensure implementation of radiation safety in all areas of application of radiation sources in all

Member States of the UN system. In practice, this is not the case. Also, IAEA is not an enforcing body. Therefore, from the global perspective, the IAEA has not achieved very much in ensuring radiation safety in the Member States of the UN system (11).

IAEA technical assistance to its Member States in the peaceful uses of atomic energy has not been faultless either. Until recently, the IAEA supplied radiation sources to developing countries without first ensuring if such countries had appropriate radiation safety infrastructures. Since 1957, the IAEA, under its Technical Co-operation assistance, supplied 550 irradiation sources to its developing Member States. This practice has now been stopped

2.5. Problems relating to supply of sources

The manufacturer of radiation sources look into the radiation safety aspects of the source. For shipment of radioactive packages, the IAEA Regulations for the Safe Transport of Radioactive Material generally apply. However, there are gaps between the supplier and the user in ensuring radiation safety. The manufacturer and the supplier are not the same body in many cases. Between the supplier (manufacturer, supplier, donating country or donating individual or institution) and the user, requirements of radiation safety are not met due often to the absence of, or inadequate national regulatory infrastructures. Often, foreign companies bring irradiation sources for industrial radiography into a country without clearance from national authorities.

2.6. Problems with sources no longer in use (spent sources)

Many radiation sources are no longer needed for one reason or the other. Hence the stock of such spent sources continues to grow in each country. The number of spent sources in developed countries is estimated to be about 100 000 and in developing countries, close to 30 000. In the absence of regulatory infrastructures, particularly in developing countries, the stock of spent sources is likely to pose problems of physical security, the chances of such sources falling into unauthorised hands or, being lost or stolen may be high The IAEA has recently taken up an activity to develop guidance on how to manage and dispose spent radiation sources, but this falls far short of offering a practical international system of control.

2.7. Smuggling of sources across international borders

Transboundary smuggling of radiation sources and fissile material has arisen as a new problem in the past few years, particularly in Europe. Some sources being smuggled are intercepted at the borders, but others may pass undetected. This new problem of international dimension requires international attention.

2.8. Insufficient authority to radiation safety personnel

It is a common experience in almost all countries of the world that radiation safety specialists occupy a low rung on the administrative ladder. At the facility level, sometimes, they may have direct access to the management, but at the national level they have little or no significant authority Therefore, their voices with respect to radiation safety regulations or practical measures are not heard However, when a radiation accident happens, the governmental authorities demand much of them. Safety personnel should have strong authority at the national level in order to help achieve effectiveness in national control of radiation sources.

3. Objectives of the International Convention

- To establish an international instrument to enforce safety and controls related to the uses of radiation sources.
- To define the responsibilities and obligations of national governments, relevant international organizations, and manufacturers and suppliers of radiation sources
- To require all countries using radiation sources to be party to the Convention.
- To require manufacturers and suppliers of radiation sources to sign the Convention.

4. Who should be Party to the Convention

- All countries of the world, irrespective of whether they are members of the UN system or not.
- All relevant international organizations.
- Manufacturers and suppliers of radiation sources.

5. Should the Convention be part of a general Convention on Nuclear Safety?

No. The interest for nuclear safety convention is for those countries which have nuclear reactors in operation or under construction. There are 56 countries which have research reactors, and 29 countries have nuclear power plants in operation and 3 countries have NPP under construction. In contrast, radiation sources are used in practically all countries of the world. In addition, the large number and diversity of radiation sources make radiation safety of sources distinctly different from that of nuclear safety. Nuclear safety and radiation safety for sources other than nuclear reactors are two different compartments.

6. How should the Convention be organised?

- Recommendation and a proposal from an international conference on radiation safety. The present conference this week is the right forum for this purpose.
- Invitation to all relevant international organizations to co-sponsor the Convention. Formation of an inter-agency committee.
- Preparation of a draft proposal by an inter-agency committee.
- Approval of the proposal by sponsoring organizations.
- Working Group to prepare the draft of the convention. Approval by the sponsoring organizations.
- Invitation to all countries of the world to sign the Convention.

7. Co-ordinating Body to implement the Convention

The IAEA should be the appropriate international organization to co-ordinate in the preparation and convening the Convention. The IAEA should also be the organization to follow up the implementation of the Convention.

8. References

[1 to 9]. International Atomic Energy Agency. Publications may be requested from the Agency.

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SAFETY ASSESSMENT TECHNIQUES APPLIED TO RADIATION SOURCES AND

DESIGN AND TECHNOLOGICAL MEASURES, INCLUDING DEFENSE IN DEPTH AND GOOD ENGINEERING PRACTICE

(Technical Session 2)

IAEA-CN-70/18

METHODOLOGY FOR SAFETY AND SECURITY OF RADIOACTIVE SOURCES AND MATERIALS - THE ISRAELI APPROACH

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1. Abstract

About 10 Radioactive incidents occurred in ISRAEL during 1996-1997. Some of them were theft or lost of Radioactive equipment or sources, some happened because misuse of Radioactive equipment and some of other reasons. Part of them could be eliminated if a better methodological attitude to the subject existed. A new methodology for notification, registration and licensing is described. Hopefully this methodology will increase defense in depth and the Safety and Security of Radioactive sources and materials. Information on the inventory of Radioactive sources and materials is essential. Where they are situated, what is the supply rate or all history from berth to grave. Persons involved are important: Who are the Radiation Safety Officers (RSO), what is their training and updating programs. As much as possible information on the site and places where those Radioactive sources and materials are used. Procedures for security of sources and materials is part of site information, beside safety precautions. Users are obliged to inform on any changes and to ask for confirmation to those changes. The same is when high activity sources are moved across the country .

2. Licensing

As the Competent Authority responsible for the Radiation Safety of the Public and Environment, Radiation Safety Division of the Ministry of The Environment is responsible for licensing the use of Radioactive sources and materials in Israel. Applicants are obliged to provide all necessary information and to take all needed steps to maximize protection. Guidlenss for applicants are based on the BSS-115[1] recommendations for public and environment Radiation Protection that were adopted by RSD[2]. Since there are other competent authorities (Ministries of Labor, Health & Israeli Atomic Energy Commission) that deal with Radiation protection, there is a need for coordination. Participants in this coordination forum are aware to the comments given to the Israeli competent authorities by IAEA committee that investigated the Sor-Van Accident.[2]

3. Coordination

(a) Competent authorities coordinate activities in a "Professional Coordination committee.
(b) Ministry of Labor oblige a yearly safety inspection at all institutes using dangerous materials, Radioactive included. Reports of all inspections are distributed also to RSD. The reports are written in a unified format. RSD had an important roll in preparing this unified format. Attachment 1 is an example of the summery of the inspection[3].

[1] Chief Radiation Safety Inspector.
[2] RSD - Radiation Safety Division Of the Ministry of the Environment

(c) Ministry of Transportation is responsible for regulations for the safe transport of dangerous materials, including Radioactive. RSD got the power, behalf of Ministry of Transportation, to implement those regulations.
(d) Ministry of health provide RSD justification for the medical aspects of Radioactive materials usage.
(e) Atomic Energy Commission is coordinated in all cases where high risk is expected.

4. Inspection

Inspection is maybe the best way to implement and enforce regulation and safety culture. Table I represents data on number of inspections done by RSD's inspector Between the years 1992 to 1997. Obviously, when a new inspector commenced inspections bearing in mind the new methodology and the need of improving defense in depth, there was 60% increase in inspections. Comparing to accumulated inspections done by RSD and all other inspectors, we can judge that RSD is doing about 60% of inspections. But it is impossible for Chief Radiation Safety Inspector of RSD to check personally and annually all Israeli institutes (over 500) for a long time. So a special inspection program planned. All institutes were divided to groups according with their Risk level. [4] According to this program, the inspector will visit only institutes of risk level "A". Information on other institutes will be provided as described in Para.2.2(b).

Table I

Year	1992	1993	1994	1995	1996	1997
Accumulated inspections	No data	No data	369	322	568	481
RSD's Inspections	163	147	138	106	312	268

5. Questioner for the applicant

Table II is the main questioner (given here in a short form) applicant has to answer when asking for a license.[5]. When the applicant face this questions, he have to give attention to different faces of safety and security:

Table II: Questioner for applicant

Site selection - safety and environmental impact assessment, regional mapping.
Practice in operation.
Reasons for practice; Justification.
Applicant's safety and Radiation Protection Organization.
Names, positions, qualifications, responsibility of Radiation Safety Officer and operators.
Description of work and process.
Project: Map, drawing, layout.
Quantification of Radionuclids, types and usage, chemical and physical form.
Description of any apparatus containing sealed sources.
Description of available monitoring equipment.
Description of storage facilities, for materials, sources and waste. Access control.
Description of waste management system.
A formal method of assessment of risks and safety analysis for all installations.
Defense in depth for all high Radiation facilities such as medical beam therapy, accelerators and similar. Also where complex wet, or other, operations are executed.

Special design and procedures for use of unsealed sources, including waste.
Manual for Radiation protection: Exposure control, dosimetery evaluation, environmental contamination, etc.
Training and updating program.
Administrative control, records, calibration, source accountability.
Movement of sources.
Physical security
Emergency response.
Special procedures for field usage of sources.
External adviser evaluation of Radiation Protection Quality assurance.

6. A methodology for license issuing

Attachment 2 describes the new methodology used by RSD to process any license request[6]. We still have difficulties implementing it. The applicants were not used to such approach and it take time to teach them to provide us the information in a way that will help us to process their applications quickly.

7. Radiography control

One of the most dangerous activities with Radioactive sources is industrial Radiography out of site, or what we define as "Radiography filming in the field". The literature is full with examples of over exposure due to wrong work procedures or sources lost. In Israel we obliged the companies executing field Radiography to **notify** us before any activity that should be done out of there facilities. Figure 2 give some idea on dose levels measured during inspections made thank to those **notifications**. Figure 3 is a short form of informing RSD on Radiography in thin field

Figure 2: Accumulated dose (μSv) at public area (distance in meters) per inspected Radiography filming:

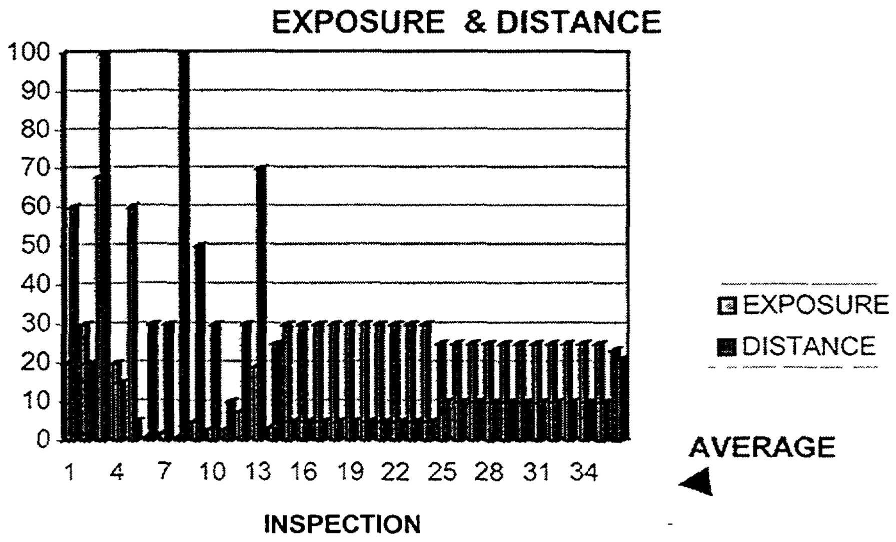


Figure 3: Announcement form

Company Name	Working Area	Endurance of Work	Repeatence?
Time of Beginning:	Technicians Names:	Source & Activity:	Other Equipment
Date: Hour:	1. 2.	1. 2.	1. 2.
A map or sketch or explanation how to arrive to filming site:			

8. Supply of Radioactive materials

Suppliers of Radioactive Materials has to inform RSD periodically on materials supplied, their activities and destinations. Table II exhibit example of monthly report of one of the suppliers: ^{99m}Tc supply in January to June 1997:

Table II ^{99m}Tc Supply of a certain supplier from 1.97 to 6.97

Month	No of Institutes	No of Generators	Monthly Activity(TBq)
January	32	258	8.62
February	32	226	6.77
March	33	246	7 66
April	33	221	6.29
May	35	258	8.16
June	34	248	7.21

9. Training

Only one School for Radiation Protection exists in Israel. During the last years it carried out about 30 courses and trained 300 people annually. The courses cover all aspects of Radiation Protection and their length is 24 t0 48 hours each. A new demand for training is prepared. According to it, three levels of training will be: 30 hours, 80 hours and 120 hours. We think this way we will improve RSO's performances.

10. References

[1] International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No.115, IAEA, Vienna,1996.

[2] The Radiological Accident in Soreq, IAEA, Vienna, 1993.

[3] Grof, I., Shlezinger, T., Ben-Shlomo, A., Barshad, M., Garty, e., Regulations for the Inspector and Checklist for Environmental and Workplace Inspection at Installations and Laboratories Using Radioactive Materials or Devices Emitting Ionized Radiation, E., Soreq NRC, 1996.

[4] Recommendations for the Safe Use and Regulation of Radiation Sources in Industry, Medicine, Research and Teaching,IAEA, Vienna, 1990.

[5] Rozental, J.J., Approval of Location, Radiation Safety Division, Ministry of The Environment, Government of ISRAEL, 1996.

[6] Abel J. Gonzalez., The New International Basic Safety Standards for Protection against Ionizing Radiation and fore the Safety of Radiation Sources, World Congress on Medical Physics and Biomedical Engineering, 21/26 August 1994, Rio de Janeiro, Brazil.

Attachment 1

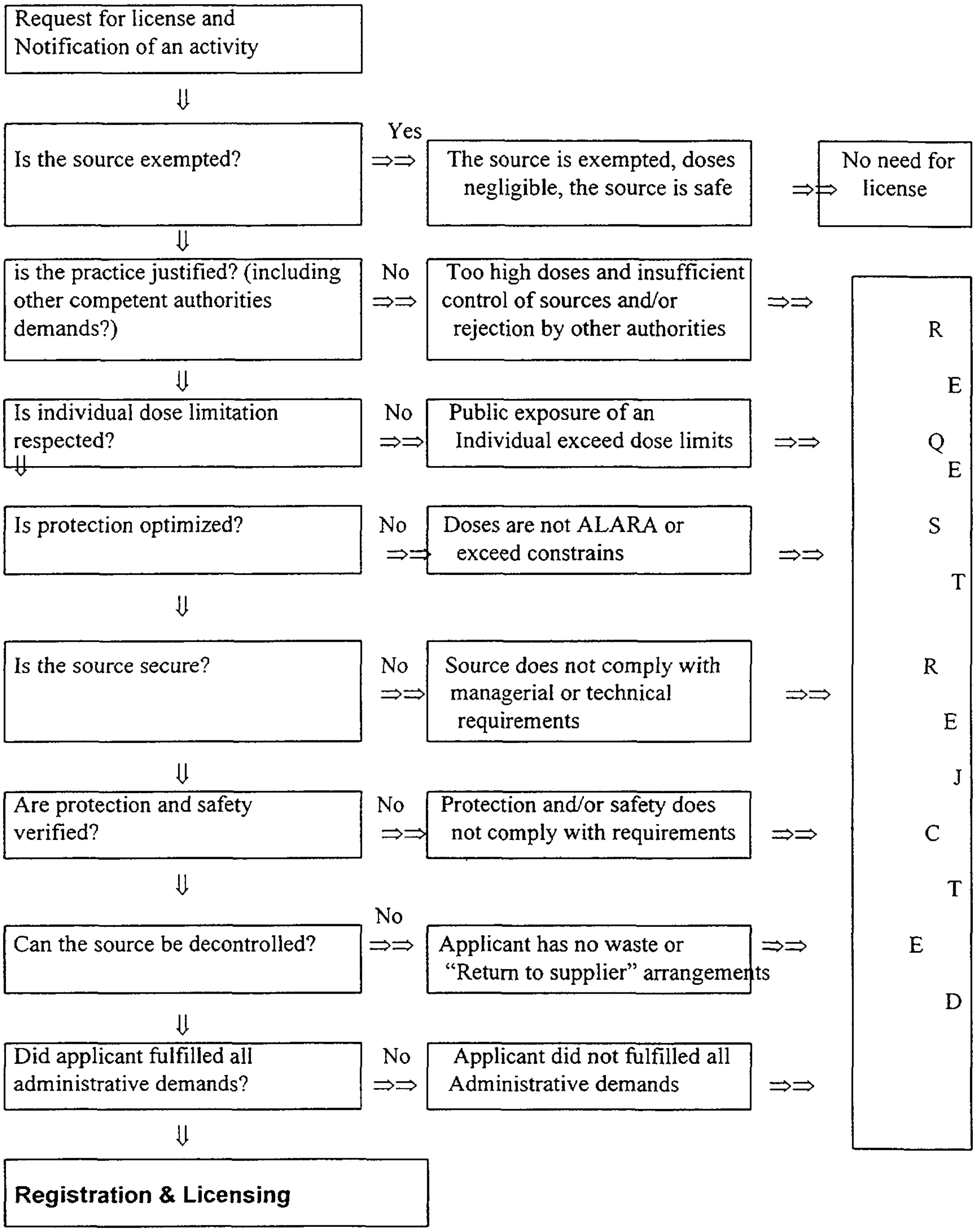
Summery Report For Ionized Radiation Installation

Address of Institution: Inspection Date:
License No.: Rso's Name: Deputy Rso's Name:
Telephone and fax:
Type of Institute:(hospital, etc.) Type of Sources:(sealed, x-ray, etc.)
Type of Inspection:(Coordinated in advance, unexpectedly, etc.)

Inspection Details

Item	Proper	Deficient	Irrelevant	Not Inspected	Comments
Licenses					
Procedures, normal and emergency					
Equipment: Proper, calibration					
Radiation & contamination levels					
Personal and area monitoring					
Leak & smear tests					
Shielding and control					
Medical exams					
Source control and report					
Access control					
Training					
RSO					
Vehicles					
Sources storage					
Waste arrangements					
Improvement comparing to last inspection?					
Other					
Recommendations to Competent Authorities:					
Signature and Declaration					

Attachment 2: Processing a license request



INTERNATIONAL CO-OPERATION IN THE FIELD OF STANDARDIZATION OF APPARATUS USING RADIOACTIVE SEALED SOURCES

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Abstract

The use of radioactive sources and equipment or devices emitting ionizing radiation covers a very large field of applications (nuclear and conventional industries, medical purposes) and needs therefore the compliance with a serial of fundamental safety requirements in order to protect the personal and the public.

The detention and the use of radioactive substances and machinery or devices containing radioactive sources are strictly controlled in the most industrial countries.

In order to harmonize the principle of use and the respect of the essential safety requirements, an international co-operation has been established since the last two or three decades in the fields of standardization and regulation implementation. It has effectively been proved that only a comparison at an international level with all of the interested people (manufacturers, safety authorities, end users, test houses, ...) will permit the publication of a set of relevant and coherent recommendations which could be adapted later on in national or international regulations by the different member bodies or international organizations These regulations will then lead the design, the detention, the use and the elimination of the radioactive sources in an appropriate manner.

France, as well as the most important industrial countries, participates actively to this effort of harmonization of good practices, namely in the field of ISO[1], CEN[2] and AFNOR[3] standardization areas, in the following domains.

1. Domains covered

International Standardization (ISO):

- ISO 3999: « Apparatus for industrial gamma radiography - Design and test criteria ».
- ISO 2919: « Sealed radioactive sources - General requirements and classification »

National Standardization (AFNOR):

- Norm NF M 62-105: « Industrial accelerators: Installations ».

European Standardization (CEN):

- Draft Standard: « Safety of machinery - Assessment and reduction of risks arising from radiation emitted by machinery », including three parts:
  - Part 1 - General principles
  - Part 2 - Radiation emission measurement procedure
  - Part 3 - Reduction of radiation by attenuation or screening

2. Interest of this international standardization co-operation

ISO and AFNOR Standardization

Concerning the fields covered by ISO, e.g. radioactive sealed sources and apparatus for gamma radiography, the different standards under preparation by ISO or published by this organization has for main objective to specify the performance criteria for their design, their

[1] ISO International Standardization Organization
[2] CEN European Committee for Standardization
[3] AFNOR Association Française de Normalisation

using and maintenance conditions and if needed their test requirements, in order to ensure safe operation conditions and to control the use of the incorporated radioactive sources, so that persons will be safeguarded when this use is made in conformity with the regulation in force regarding radiation protection point of view.

The french standard concerning industrial accelerators has approximately the same objective, that means to precise the criteria for the design and for the construction of the industrial installations in order to ensure the safety of the operators and the environment against the direct risks or the induced risks linked to the ionizing radiation emissions.

European standardization

The improvement of the serial of standards concerning the assessment of risks arising from radiation emitted by machinery has been undertaken in the frame of the "Machinery Directive" which recommends to the manufacturers and the safety authorities, to quantify if possible in the product standards, the emissions which are detrimental to health, with regard to the following principles:

- to reduce the risks to the lowest possible level (principle of risk reduction to the lowest possible level according to the ALARA principle),
- to inform the user of the existing residual risk (principle of user information).

This quantification enables the manufacturer to assess the state of the art in terms of the risk generated by his product or equipment, to the most suitable measures for reducing the risks and to inform the user of the scale of the remaining risks.

Considering this principle, the experts who have been requested to write this serial of standards referenced here above, have proposed a very original methodology for the assessment and the reduction of the risks arising from radiation emitted by machinery (these radiation could be ionizing radiation or non ionizing) which is based on the categorization of the machines according to the level of the radiation emission and on the inventory of the protection means which could be adopted for the prevention and the reduction of the remaining radiation emission.

Part 2 and 3 of this standard, which complete the main part of the previous standard, specify respectively the procedures for measurement of the radiation emission and a set of appropriate protective measures which lead to prevent and limit the exposure of the people by reduction of the remaining radiation by attenuation or screening or by taking into account complementary protective measures during operation.

Note: For all of the above mentioned standards, the application of the proposed recommendations shall be completed by the obligation of the compliance of the suitable regulations concerning, on one hand, the radiation protection requirements (limitation at the lowest possible level of exposure) and on the other hand, the transport requirements (for example application of the IAEA regulations for the safe transport of radioactive materials).

3. References

[1] Nuclear and Radiation Protection Standards - Catalogue and Classification - K. Becker and N. Fichtner, Revision 1995, Beuth Verlag GMBH Berlin Köln.

[2] European « Machinery Directive » published by the CEE Organization (Directive CEE 89/389 and its amendments).

[3] Annual 1997 Report of ISO/TC 85 « Nuclear Energy », ISO Publication, Geneva/Switzerland.

[4] Equipements de Travail - Moyens de Protection / Guide Juridique, Tome 1 et 2- Journal Officiel de la République Française, Edition 1997.

MANAGERIAL MEASURES, INCLUDING SAFETY CULTURE, HUMAN FACTORS, QUALITY ASSURANCE, QUALIFIED EXPERTS, TRAINING AND EDUCATION

(TECHNICAL SESSION 3)

IAEA-CN-70/58

THE NEW ORPHANED RADIOACTIVE SOURCES PROGRAM IN THE UNITED STATES

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Abstract

Exposure of the public to uncontrolled radioactive sources has become an significant concern to the United States (US) Government because of the continuous increase in the number of sources that are being found, sometimes without proper radiation markings. This problem is primarily due to inadequate control, insufficient accountability, and improper disposal of radioactive materials. The US Environmental Protection Agency (EPA) has funded a cooperative „orphaned" source initiative with the Conference of Radiation Control Program Directors (CRCPD) to bring under control unwanted sources and thus reduce the potential for unnecessary exposure to the public, workers and the environment. The program is being developed through the cooperative efforts of government agencies and industry, and will provide a quick and efficient method to bring orphaned sources under control and out of potentially dangerous situations.

1. Background

The United States (US) uses about 90 million metric tons of steel annually. About half of that metal comes from recycling. It is important that the metal be as free from contamination as possible. US Department of Energy (DOE) facilities and nuclear power plants which are decommissioned are potential sources of millions of tons of metal that could be recycled. In addition, there are nuclear facilities around the world that are being dismantled, and the metal sold for scrap.

The US Environmental Protection Agency (EPA) has a mission to protect people and the environment, and so began a study to determine any potential effects on the public of recycling the metal from these facilities. As EPA investigated the domestic metal recycling process, they became more concerned about two additional potential sources of contamination in metals: contaminated metal from foreign countries, and sealed radioactive sources, both domestic and foreign, that become mixed into the scrap metal stream (orphaned sources). This paper discusses a new program that is intended to reduce the number of radioactive sources that enter the scrap metal stream in the US.

2. PROBLEMS WITH SEALED RADIOACTIVE SOURCES

Sealed sources in the US are the responsibility of the Nuclear Regulatory Commission (NRC) and individual states which have assumed this authority (NRC Agreement States), and fall into either of two categories: (1) specifically licensed devices, and generally licensed devices. Generally licensed devices, in contrast to the specifically licensed devices, are subject to minimal regulatory oversight, and sometimes, inadequate control. As a result, there could be as many as 30,000 radioactive devices lost or otherwise unaccounted for („orphaned“) in the US today (exact figures are not available since there is no comprehensive registry). Some of these orphaned sources find their way into the general public domain or commercial scrap metal stream, while others may end up in municipal waste disposal facilities. Scrap metal handlers and some landfill operators have installed radiation detectors in an attempt to locate these orphaned sources before they enter the facilities. The EPA is concerned that the lack of uniform guidance and regulatory control of all radioactive devices have caused unnecessary contamination as a result of improper disposal by the source owners. This carelessness has caused injuries to workers and members of the US public has while costing millions of dollars for remediation.

Since 1994 over 2,500 incidents of radioactive material found by the metal recycling industry have been reported. Since 1995 there have been about 50 sealed sources found annually in the US by members of the public. Although over half of the radioactive material found in recycled metal scrap is in the form of naturally occurring radioactive material (NORM), this effort is mostly concerned with sealed radioactive sources or discrete radioactive sources that would, when breached, potentially pose significant risk for the unsuspecting members of the public or industry workers. Recently in the US, industrial radiography devices containing ^{60}Co and ^{192}Ir sources were stolen and sold as scrap metal. People who were exposed unnecessarily to the source may have received doses up to 100 mSv (10 rem).

The US has an emergency response program to ensure that radiation sources that pose an immediate danger are brought under control. Fortunately, most sources are discovered before they become a health threat. In the US, the individual who discovers a source is responsible for the disposal of the source, unless he can find the owner. Because of the lack of a nationwide coordinated program to find economical reuse or disposal options for sealed sources, government agencies have begun to find sources lying along highways, discarded on vacant land, or intentionally hidden by scrap metal while being sent to recyclers.

3. NEW ORPHANED SOURCES PROGRAM

The EPA decided that a better system was needed to protect the public. EPA discovered that the Conference of Radiation Control Program Directors (CRCPD), an organization of state and local government personnel responsible for radiological health programs in the US, had begun a program to help find new owners for unwanted sources. EPA teamed with the CRCPD and provided funding to expand that program nationwide to include all „orphaned“ sources. CRCPD, with assistance from Federal and State agencies and industry, is developing and will administer the program. The major planned activities include the following:

(1) Conduct a survey to identify sealed source types and potential quantities;
(2) Investigate source management problems and find alternatives to present systems for control and disposition of sources;
(3) Develop a user friendly and easily maintained nationwide sources database;
(4) Develop a program for efficient and cost effective disposition of orphaned sources; and
(5) Expand outreach to the widest possible audience for source identification, availability of sources no longer needed by the current owner, and disposal options for sources.

3.1. Progress to Date

In October 1997, a committee was formed of state and federal personnel to develop a streamlined approach to disposition orphaned sources by reuse, legal transfer, or burial. First, a definition for orphaned sources was developed: an orphaned source is a discrete source of radioactive material that is either (1) in the possession of an unlicenced entity; (2) in the possession of a licensee not authorized for the material; (3) in the possession of a licensee, but there is little confidence that the source will remain secure (e.g., bankrupt licensee), or (4) has no legal disposal option.

Next, the committee conducted a survey of sealed sources which had been found and stored on an interim basis awaiting final disposition either through reuse or burial. The survey is intended to establish a source inventory for disposal prioritization. If no responsible party can be identified with resources for disposition then a determination is made by the committee about whether to fund the disposition based upon a qualitative assessment of stability (containment, shielding, form of source, and leakage/contamination) and the capability of the custodian to maintain the source.

The committee has begun work on a single database which will be used to track all orphaned sources found in the US. This database will be accessible via the Internet for government officials, waste brokers, and qualified licensees seeking sources. In addition, it is envisioned that owners will post information about lost sources, allowing authorities and scrap brokers to be on the lookout for the missing devices. The database is expected to be operational by the fall of 1998. EPA is also working with other US federal agencies to provide better detection capabilities for sources misplaced in scrap metal.

3.2. Upcoming Work

The next phase of the orphan source initiative is to provide extensive outreach programs though the Internet, hand books and magazines to increase awareness of both industrial organizations and the public about the dangers of sources, and the availability of resources for the proper disposal of sources. US industry is cooperating by providing information they have developed on identifying sources, which will be combined with government materials and guidance on using the newly developed procedures for source disposal. The outreach program will include information to help identify radioactive sources even in cases where the warning markings have been removed.

4. OTHER ORPHANED SOURCES INITIATIVES

In addition to the primary orphaned source initiative described above, the NRC is working to tighten its regulatory oversight of generally licensed devices for better accountability by 6,000 general licensees. A proposed rule is being developed that will require licensees to pay fees for future disposal, require permanent labeling, impose civil penalties for lost devices that will be greater than disposal cost, and apply more stringent housekeeping inspection requirements of licensees with general licenses. However, several NRC Agreement States have already imposed stricter requirements, and have seen a noticeable improvement in source accountability.

5. Related action needed

World-wide markets and distribution of raw materials and finished goods have resulted in problems going beyond national borders. Further, countries increasingly are becoming concerned about potential terrorist use of radioactive materials. It is important for all nations to become more aware of the need to control radioactive sources, and to take measures to ensure their control. In addition, an international clearance standard implemented by all nations is needed for addressing allowable clearance levels for radioactivity in metal.

6. Conclusion

The orphaned sources program being developed in the US will provide a timely and efficient method for bringing orphaned sources under control. The dissemination of information to the public and industry will increase awareness of the problem and help to ensure that sources are brought under control promptly. The improved oversight of licensed devices by the NRC and the NRC Agreement States will, over time, help reduce the number of sources that become orphaned. However, while improvements in licensee and regulatory performance with respect to control and accounting will be expected as a result, given the huge population of radioactive devices in the US, the total elimination of all incidents pertaining to the loss of control of radioactive devices is not realistic. Awareness and vigilance by the public and industry must increase, and the continuation of the CRCPD program will remain a vital component of radiation safety for the public. Finally, international action is necessary by all nations to control sources and for addressing allowable clearance levels for radioactivity in metal.

For more information on these issues please contact EPA's world wide web site on the Internet at http:/www.epa.gov/radiation/scrap.

INFORMATION SYSTEM FOR THE MANAGEMENT OF A REGULATORY PROGRAMME

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Abstract

A Regulatory Programme to monitor safety of activities involving radiation sources, implies the existence of a Regulatory Authority empowered by legislation to issue radiation protection regulations and to monitor compliance with those regulations. An core element of the programme is a system of notification and authorization (registration and licensing), inspection and enforcement. The efficiency of this system is largely dependent on the availability of reliable information on the inventory of radiation sources and installations, the administrative status of the facilities (authorization), prompt processing of inspection reports and follow up of regulatory actions, including monitoring deadlines. Essential data relevant to safety, such as personal dosimetry for occupationally exposed individuals, inspection findings and incident reports would provide, in addition, an insight on the overall safety of the country. A simple but comprehensive Regulatory Authority Information System (RAIS) linked to the authorization and inspection process will largely facilitate regulatory decisions and actions. A readily available and reliable information from the various regulatory activities will facilitate planning, optimization of resources, monitoring safety related data, disseminating safety information, making decisions and follow up regulatory actions including monitoring dead lines. The implementation of the system in more than 50 countries will contribute to experience exchange and harmonization of regulatory activities.

1. Introduction

An adequate regulatory safety infrastructure requires the existence of a Regulatory Authority, established by legislation and a Regulatory Programme, which consists of the following basic elements:

- Regulations, which establish the requirements and standards of safety
- System for notification and authorization (registration and licensing)
- Compliance monitoring, including inspections
- Enforcement actions to compel compliance with regulatory requirements
- Investigation of accidents and management of emergencies
- Dissemination of information related to the safety of sources

The Regulatory Authority needs prompt and updated key information for the planning of these activities and for ensuring confidence that resources are optimally used. This information consists of : location and ownership of all radiation sources, so that no source escapes the control; the authorization process; classification of facilities by frequency of inspection according to risk level; follow up of findings of inspection and enforcement actions, including monitoring of dead lines; knowledge of average dose values for occupational exposure. Finally the Regulatory Authority needs to periodically report on its activities and on the safety status in the country.

With these needs in mind, the IAEA has developed the Regulatory Authority Information System (RAIS), which is being simultaneously introduced in 53 countries, receiving assistance under the Model Project on Upgrading Radiation Protection Infrastructure, but is available to other countries upon request. The design requirements were that the system should be simple to ensure prompt and regular updating; and comprehensive enough to avoid parallel systems on the same issues that otherwise would naturally emerge. The system should also be flexible enough to be suitable to various size and complexity of regulatory programmes. The RAIS consists of five modules that are described below.

MODULE 1: INVENTORY OF RADIATION SOURCES AND INSTALLATIONS

Module 1 includes the location and relevant data of each individual source and radiation generator, as well as the installation to which the sources belong. The basic report provides a list of all sources within any installation, classified by practices. RAIS is particularly useful for dissemination of safety information to licensees, for example, a warning or a request for action to all facilities that use given type of equipment, or to all installations having a given practice (for example, all radiotherapy installations).

RAIS keeps track of sources that are associated to an equipment, which is especially important, when sources are replaced and the associated equipment remains at the facility, with the new source. It also allows for multiple sources associated to a single equipment (as is the case for source trains in remote control brachytherapy). The system provides the history of a source, in cases that sources are transferred to another facility or are returned to the origin or sent to be managed as radioactive waste.

It is not practicable to keep centralized updated records of movement of sources of short lived radionuclides or unsealed sources. An example are Mo-99/Tc-99m generators that are received every week and diluted for many patients, or Ir-192 wires that can be cut into smaller sources as needed. This is not a limitation of RAIS, but a limitation of the nature of the subject. Inspectors will have to look at the records at the installation. RAIS indicates, in this cases, the maximum authorized activity, as an aid for the regulatory control.

MODULE 2: AUTHORIZATION

The system keeps track of the administrative status of the authorizations, from the application until the authorization is granted, with intermediate steps, such as requests for additional information from the applicant and pre-operational inspections.

Registrants and licensees may apply for modifications or expansion of an existing authorization, or total or partial decommissioning. To cover these possibilities, the system keeps the administrative history of the installation. If a source is being transferred to another installation, RAIS will request entering the authorization data of the recipient, to ensure that only authorized users may receive sources. The history of a source is kept as well.

The actual document of authorization can be prepared through RAIS. If this approach is followed by the Regulatory Authority, it would benefit from updating of RAIS data at the same time the authorization is issued.

MODULE 3: INSPECTION AND ENFORCEMENT

The frequency of inspections should be tailored to the potential exposures (the type of practice) and to the safety history of a given installation. This implies to classify the practices in categories of risk and to record the history of inspection findings. Both elements are part of RAIS.

Basic reports include a list of inspections made within a certain period of time and also those that should be carried out in a coming period (it should be noted that average frequency does not imply inspection after a fixed period or dates; inspections should be either unannounced or notified), classified by practice and geographical location. In addition, enforcement actions and dead lines are kept as well.

Inspection reports and follow up document can be prepared through RAIS. If this approach is followed by the Regulatory Authority, it would benefit from continuous updating of RAIS data.

MODULE 4: PERSONAL DOSE MONITORING

The Regulatory Authority needs information on occupational exposure for monitoring safe operation. Dosimetry services may be governmental, but also private institutions, monitored by the Regulatory Authority. In any case, summary reports or, in some countries, the complete individual dosimetry data are available to the Regulatory Authority.

The quantities used in individual dosimetry have to be consistent with the quantities in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. The use of RAIS presumes that dosimetry services report doses in operational quantities such personal dose equivalent Hp(d). For assessment of effective dose, the value Hp(10) is the most relevant. Depending on the type of radiation, a conversion factor to estimate effective dose from personal dose equivalent, will be needed. RAIS will then perform the automatic computation, provided that Regulatory Authority decides on practice specific conversion factors.

When protective clothing is used, such as lead aprons, and heavy workload as interventional radiology, a person may wear more than one dosimeter; each of the dosimeters will have a different conversion factor to account for its contribution to effective dose. For this purpose, RAIS allows for more than one dosimeter and more than one conversion factor, to automatically calculate effective dose as a linear combination of both values.

In addition, monitoring local dose (eye lens, skin) may need separate monitoring, the personal dose equivalent can be evaluated for different depths, such as 3 and 0.7 mm. RAIS allows therefore for those circumstances as well. Finally, a person may work in two different facilities, for which both dose records are to be kept separately. The system provides the history of the workers as well.

RAIS provides comparison with reference levels such as dose constraints, investigation levels or with dose limits and reports provide information on doses exceeding the levels.

MODULE 5: PERFORMANCE INDICATORS

2. Information related to the Regulatory Authority

To monitor efficiency of the Regulatory Authority, the following RAIS reports will be useful to the Regulatory Authority: lists of authorizations processed, mean time elapsed by an authorization process, depending of the practice, and the list of applications in process; list of inspections, by practice and geographic area, by each inspector, enforcement actions, and list of ongoing actions with dead lines.

RAIS will also be useful in producing periodic summary reports of activities, for institutional supervising bodies.

3. Information on individual facilities

RAIS is useful to produce the basic information relevant to safe use of sources consisting of the occupational doses by practice, the doses exceeding dose constraints, investigation levels and dose limits, history of incidents and non compliance, and the history of enforcement actions.

4. Global information

Also in a global manner, occupational dose distribution by practice, doses exceeding dose constraints, investigation levels and dose limits in the country, list of incidents and non compliance and enforcement actions will be obtained from RAIS.

RAIS can also handle other information on the overall activities in the country, relevant to safety, such as a list of training courses on radiation protection, delivered under the monitoring of the Regulatory Authority, with list of attendees, list of radiation protection officers and other qualified experts, needing control of the Regulatory Authority (some countries may have personal licenses, or registration).

5. Summary and conclusions

A readily available and reliable information from the various regulatory activities is an essential tool for planning, optimization of resources, monitoring safety related data, disseminating safety information, making decisions and follow up regulatory actions including monitoring dead lines.

With the option of issuing the authorization document, inspection reports and enforcement actions, RAIS will ensure a harmonized, continuous updating, reliable information system for the managers of regulatory authorities.

The approach of implementing the system in 53 countries simultaneously will bring about a unique opportunity for a synchronised progress, harmonization, experience exchange and comparison of regulatory information, updating and "helping each other" at regional level, that will contribute to efficiency in the implementation of the regulatory programmes.

The use of RAIS combined with the harmonization of dosimetry services to use the BSS operational quantities will allow a fast improvement in comparison of world wide dosimetry data.

Periodic or ad hoc official reports on the regulatory activities and about the status of safety in Member States will be facilitated through the available of reliable quantitative information using RAIS.

Finally, the information system will contribute to an easy monitoring of progress of projects on upgrading regulatory infrastructures in Member States.

IAEA-CN-70/24

DEVELOPMENT AND REALIZATION OF THE NEW STATE SYSTEM OF ACCOUNT AND CONTROL OF RAM AND RAW

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Abstract

In the article the principles of organization, organizational structure and main functions of the automated system of the state account and control of radioactive material (RAM) and waste (RAW), which is developed now in Russia, are presented. On the base of analysis the existing («paper») system the acute necessity in automation of processes of an account and control ĐÂ and ĐÀÎ, based on use of modern information technologies is shown. There are presented a structure and content of normative - legal, program and information parts of the system and milestones of designing it.

1. Existing practice of account and controle of rm and raw

To the end of 80-s in the Soviet Union arose a sufficiently integral system of account and control of RAM and RAW, some elements of which is in force until now. At the present time the account and control in Russia is performed directly at enterprises handling RAM and RAW under the control of supervisory bodies.

The main supervisory bodies of Russia engaged in the state regulation of safe management of RAM and RAW are Gosatomnadzor of Russia and Gossanepidnadzor of Minzdrav of Russia. Gosatomnadzor is responsible for issues of licensing and technical aspects of radiation safety. Gossanepidnadzor specialises in the matters of radiation hygiene and radiation safety of population.

Account and control of RAM and RAW are performed on a basis of federal laws "About using atomic energy" and "About radiation safety of population". Issues of radiation hygiene and a number of other matters of radiation safety of management with RAM and RAW are regulated by "Basic sanitary rules of work with radioactive substances and other ionising radiation sources, OSP-72/87" and "Radiation safety regulations, NRB-96".

Using sealed radioactive sources (SRS) as an example, we will contemplate the scheme of account and control system existing now in Russia. Individual registration at enterprises-producers and enterprises-users is obligatory for each SRS with the activity more then exemption level defined in NRB-96 (the same level as in Safety Series No. 115, table 1-1, IAEA, 1996).

All enterprises and organizations dealing with the handling of SRS, whose radionuclide activity exceeds exemption level, must have a license from Gosatomnadzor of Russia, as well as permission from Gossanepidnadzor for working with specified sources (sanitary passport). Any delivery and handing of SRS can be carried out only under permission of Gossanepidnadzor bodies. It is also necessary to inform local bodies of MVD (Ministry of Internal Affairs) about any handing of SRS.

On receipting SRS an enterprise has to notify in 10-days period about it to the local bodies of Gossanepidnadzor and MVD. A supplier of SRS must obligatory warn a customer about the shipment beforehand. Administration of enterprise handling SRS is responsible for the preservation of sources and have to provide the conditions of storing, acceptance, use, consumption and decommissioning that exclude the possibility of losses and unauthorized using. SRS are delivered with passports pointing out technical characteristics (for the time of production) and expected service term of SRS. The passport shall accompany the SRS throughout its life cycle up to the moment of its utilization or disposal. Gossanepidnadzor bodies are charged with a mission of control of SRS service term.

On delivering to an enterprise SRSs are to be accepted by an authorized person appointed by order of the enterprise head. This person keeps a systematical record of the availability of SRSs and handing f them within the enterprise in accordance with the special forms. All devices, facilities and installations involving SRS are accounted in a registry according to a specified form as well. A records keep radionuclide names, activity and serial number of SRS. Any transfer of SRS from its storage to users is done only under a written permission of the enterprise head or an authorized person. Issuing and return of SRS are recorded in the registry. The executives are responsible for the preservation of SRS from the reception to the return or writing of it.

Annually a commission, nominated by the enterprise head, performs an inventory of SRS. In the event of detection of SRS loss information about it should be transmitted immediately to bodies of MVD and Gossanepidnadzor.

Obviously that such system of account and control could manage reliably (but very slowly) with a relatively small number of "good" state enterprises which handled RAM and RAW. Evidently as well that any integrated qualitative and quantitative assessments of availability and status of RAM and RAW at a federal or regional level could be made extremely delayed.

On disintegrating the USSR the situation of RAM and RAW account and control have been complicated significantly due to collapsing of long-standing relations. Moreover, in the at transition to market economy RAM products began to be manufactured by enterprises belonging to various types of ownership. Furthermore, numerous commercial companies have been deeply involved in sales and transport. Often these enterprises have neither sufficient experience of account and control nor technology and production base ensuring safety. It gives rise to potential radiation accidents, uncontrolled transfer and theft of RAM. It has become obvious that the system in force doesn't allow for a complete account and control of RAM and RAW.

Under these circumstances there is acute necessity to very improve RAM and RAW account and control at all stages of their existence: production, use, transport, processing, utilization, storage and disposal.

In line with the Federal law "About using atomic energy" and an appropriate resolution of the Government from the end of 1997 such system (hereinafter - State system) has been developing under the direction of DBEChS of Minatom of Russia.

2. Purposes and tasks of state system

The purpose of establishing the State system is to organize account and control of RAM and solid and liquid RAW at federal, regional and department levels including various items with RAM and RAW and transport packagings (TUK) at all stages of their existence. The main tasks of the system are as follows:

a) determination of the number, structural and qualitative composition of RAM and RAW at their localities;
b) locating any registered unit of account of RAM and RAW;
c) reporting to state organs an integrated information on availability and transfer of RAM and RAW including export and import data.

To resolve these tasks it is necessary to develop a complex of regulations and software/ hardware means providing:

a) establishment of rules, standards and procedures on order of operating State system;

b) creation and keeping state register of RAM and RAW in Russia, state cadastre of sites of storage and disposal of RAW;
c) creation and keeping databases of specific units of account of RAM and RAW (made,used, at storage, processed, transferred within Russia and outside Russia).
d) Considering that the volume of information circulated within the system will be quite large and the mentioned functions must be executed operatively State system shall be based on the modern information computer technologies.

3. Regulatory and legal provision

Regulatory and legal provision of system should consist of the whole complex of regulatory documents, statutes, governmental decrees and other documentation ensuring the functioning of State system in the legal field. It includes such fundamental documents as:
a) statement on the State system of account and control of RAM and RAW;
b) statement on the State information-analytical centre, typical statements on regional and departmental information-analytical centres of account and control of RAM and RAW;
c) regulatory documents including rules, standards and procedures that define an order, range and structure of information about RAM and RAW prepared and reported by enterprises to appropriate information-analytical centres;
d) regulatory documents defining conditions and procedures for converting RAM into RAW category;
e) regulatory documents including rules and requirements to measurement methods that provide account and control of RAM and RAW.

4. Software tools for the state system

Design and development of different databases comprising the information core of State system should be carried out with the use of modern database management system (DBMS) that will have the possibility to operate multitabulated databases and ensure an effective selection and processing of stored data.

This DBMS would comply with the following essential features:
a) to provide uninterrupted operation and support of work with very large data sets;
b) to provide wide selection of means for generation of applied information systems of decision making support and systems of real time transaction processing;
c) to provide interaction between DBMS and packaged programs for calculation of activity and other radiation characteristics;
d) to provide protection against failures, fetch and casual data damages;
e) to provide possibility of using the most significant RAM and RAW databases existed at various enterprises and databases developed and projected under the aegis of IAEA.

As a tool for development of State system the programming system Visual FoxPro-5.0 was selected.

To realize State System functions the software should include the following subsystems:
a) account and control of sealed radioactive sources (SRS);
b) account and control of radioactive raw materials and semi-finished items (RM);
c) account and control of radioactive preparations (RP);
d) account and control of solid radioactive waste (SRW);
e) account and control of liquid radioactive waste (LRW).

As important component of RAM and RAW account and control is its transport the State system has also to incorporate a subsystem of accounting for certificates-permissions for RAM and its shipments and a subsystem of TUK account. In addition, for the complete description of an object of control and account one needs to make an information-analytical description of an enterprise-owner and a place of source's using/storing. Therefore, State system should also include a subsystem for keeping information at enterprises. In such a manner software of State system should have a structure shown in Fig.1.

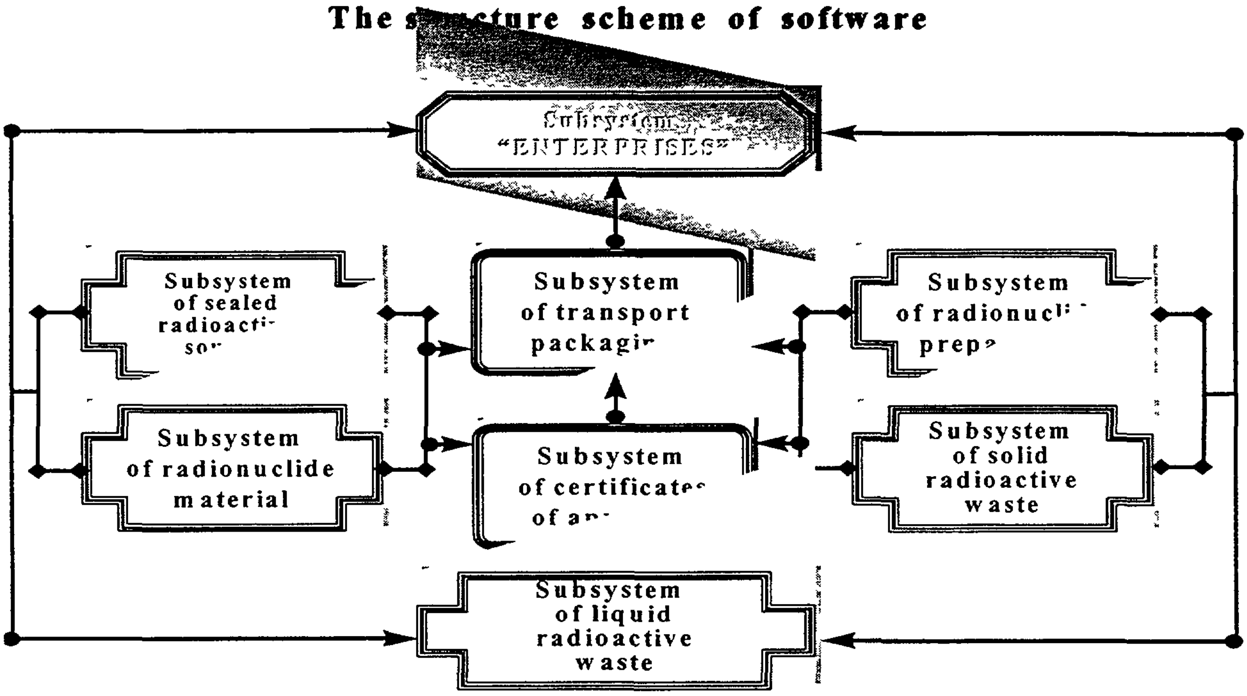

Fig.1

5. ORGANIZATIONAL STRUCTURE OF STATE SYSTEM

In State system there are four levels of RAM and RAW account and control: federal, regional, departmental and the level of enterprise. To realize it there is a need to create appropriate management organs and information-analytical centres of collecting, processing and transmission of information which would provide the functioning of State system at all levels.

Management organ of the system at a federal level is a State information-analytical centre (SIAC) that is oganized in DBEChS of Minatom. Main functions of SIAC are:

a) Scientific, methodological and software developments with the purpose of creation and modification of account and control system at all levels;

b) Collecting and processing information from enterprises and information-analytical centres of other levels;

c) Preparation of information on request of users of account and control system;

d) Preparation of regulatory-legal acts draft concerning the provision of account and control, coordination and approval in federal executive bodies;

e) Coordination of efforts of departmental and regional information-analytical centres.

SIAC consists of management organs and two analytical centres of account and control: for RAM and for RAW. These information-analytical centres fulfil the functions of development, elaboration and guidance of scientific and methodological provision and software for State system, its analytical functions (analysis of incoming information, composition and validity check, recovery of information based on data from different sources, search of lost RAM and RAW, analysis of trends of transitions, accumulation, export, import, issue of reports etc.).

Departmental information-analytical centres (DIAC) are organized at ministries (departments) covered by the system of account and control. Each such department will determine (agreed with Minatom) its basic enterprise that has appropriate technical and scientific-methodological possibilities. This enterprise is responsible for the implementation of the system of account and control within the department and, if need be, executes analytical functions of the department itself. The main functions of DIAC are:

a) collecting and processing information from enterprises belonging to the department;

b) data transmission to the State information-analytical centre;

c) preparation of departmental regulatory and legal act drafts on account and control, its agreement and approval at appropriate departments;

d) coordination of efforts of subordinate enterprises in the field of account and control;

e) preparation of proposals on improving the system of account and control and presentation them to the State information-analytical centre;

f) implementation of scientific and methodological developments and software products in the field of upgrading of account and control system that are developed in the State information-analytical centre.

Regional information-analytical centres (RIAC) will be organized in all administrative subjects of Russian Federation under Gossanepidnadzor organs located in appropriate regions. The main functions of RIAC are similar to ones of DIAC but cover appropriate region.

Account and control at the level of enterprises is fulfilled in accordance with the typical statement of RAM and RAW account and control at enterprise, developed in the frame of State system. RAM and RAW account and control centres at the level of enterprises have to be organized only at the enterprises which have significant production or using of RAM and RAW. They are provided by necessary software of State system.

Enterprises with small volume of RAM and RAW production/consumption and not having appropriate technical means will organize paper record and transmit information to information-analytical centres in the form of text files according to special registration forms.

In accordance with this structure of State system the following order of its functioning is determined:

a) information from off-departmental enterprises is presented to regional information-analytical centres and State information-analytical centre (or to one of its branches);
b) information from departmental enterprises is presented to regional and departmental information-analytical centres;
c) integrated information from regional and departmental information-analytical centres is presented to State information-analytical centre.

Thus, State information-analytical centre collects information through three channels: through the regional bodies, through the departmental bodies and directly from enterprises. As a result a reliable control for information validity is provided at the federal level.

6. INFORMATION PROVISION OF STATE SYSTEM

Information provision of State system is formed through various procedures and software.

1. An initial data collection of RAW and RAM will be performed in 1999 at the stage of development of software tools for State system. With this object in view all enterprises possessing RAM and RAW will carry out the inventory in the first quarter of 1999. Two

methods of inventory are designed: almost computerized one and «quasimanual» (using text system WORD 6/7) one similar as it was shown above for large and small enterprises.

2. An analysis of collected data for validity, a search for missed (not registered) RAM and RAW, correction and updating of information will be done in 2000 at the stage of experimental operation of State system. Collecting and processing of data at information-analytical centres of all levels will be made by using of an unified software that is now under development in the context of State system. Data transmission from enterprises, regional and departmental centres to State centre is carried out on request during all the period of experimental operation of account and control system. Information is transmitted via electronic communications networks. Enterprises not having a computerized account of RAM and RAW at the stage of pilot operation are transmitting information to appropriate centres in depend on its, but not less than quarterly.
3. After putting State system into full-scale operation (in the end of 2000) data transmission from enterprises keeping a computerized account, from regional and departmental centres to the State centre will be carried out continuously no less often than once a week. If need be, an operative data exchange can be performed via electronic communications network. Enterprises not keeping a computerized account of RAM and RAW are transmitting information to appropriate centres depending on its changing but not less than once a month.
4. On the base analysis of information received State information-analytical centre will determine for each enterprise a period of next inventory. In the event of the detection of invalid data transmitted from an enterprise an extraordinary inventory could be prescribed.

7. CONCLUSION

Prototyping of software for State system in the first half of 1998 and progress towards the development of the basic documents and a comparatively successful process of initial data collection make it possible to express the assurance that the development of the State system of RAM and RAW account and control will be completed in 2000.

LA GESTION DES SOURCES RADIOACTIVES AU CEA

J.C CARIES

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THE FOUNDATION OF COMPUTER BASED CLOSED RADIONUCLIDE SOURCES TURNOVER CONTROL SYSTEM IN MOSCOW CITY REGION

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Abstract.

This paper concerns the problem of Closed Radionuclide Sources (CRS) automated account and control in Moscow city and Moscow region. Information relations structure between authorities and enterprises is shown. Special computer oriented system of CRS turnover monitoring is used for this purposes. Its possibilities and numeric characteristics of database are mentioned. This system benefit and application aspects are discussed in detail.

1. Introduction.

The problem of radioactive materials (RAM) and radioactive wastes (RAW) turnover control is of a great importance. Now federal system of them account and control in Russia still is creating. But Moscow metropolitan district (Moscow city and Moscow region) with population near 15 millions peoples has own program of Closed Radionuclide Sources (CRS) account and control which is the main part of RAM and RAW turnover monitoring system.

2. The base of the CRS turnover control system.

According to Moscow city and Moscow region administrations decisions Moscow Science and Production Association (MSPA) «Radon» has a commission to solve a problem of Closed Radionuclide Sources regional account and control. For this reasons the typical automated computer oriented system of CRS turnover monitoring was developed and realized in MSPA «Radon». Since 1991 this system provides the closed-loop CRS turnover control from the moment of their receipt by enterprises (from the «birth-day») till the final localization (till «death»), by means of it's main parts: system of CRS and CRS-based devices accounting and there's owners control, radioactive wastes suppliers accounting with radioactive wastes generation process analysis and, finaly, radioactive pollution sources monitoring system, including account and analysis of illicit CRS manipulation accidents.

Now this system provides the work of Regional Information Analytic Center, which is in close connection with State Atom-Inspection Depts., Sanitary and Epidemiological Inspection Depts., Civil Defense and Emergency Affairs Headquarters, Federal Security Service, Ministry of Internal Affairs Depts., Moscow Ecological Police etc. Information relations structure is shown at Fig.1.

3. System characteristics and possibilities.

At present the databases of the system contains the information about more then 700 Moscow city and Moscow region enterprises, possessing more then 200 000 CRS, and more then 2000 RAW suppliers under service of MSPA «Radon» including enterprises from 10 other regions of the Russia centre area..

The information system permits to conduct the data analysis, concerning the various aspects of CRS storage and operation at enterprises of the city and region. The joint data processing about localized and maintained CRS identifies «out of date», lost or «conditionally lost» sources. It enables authorities to conduct the operative control at correctness of CRS use, as well as to accept regular decisions about «out of date» CRS replacement and localization planning.

The CRS turnover monitoring system is realised in Microsoft Access and is counted on unprepared users. This system operation experience is proved its high effectivity.

The great amount of detailed and generalized information is available additionally.

4. Conclusion.

The automated computer oriented system of CRS turnover monitoring was created in MSPA «Radon» and is exploiting since 1991 for Moscow city and Moscow region. It provides the work of Regional Information Analitic Center. Having information about more than 200 000 CRS, this system gives possibilities both for autoriries to control the CRS use and for enterprises to plan CRS replacement and localization. The system exploitation experience is proved its high effectivity.

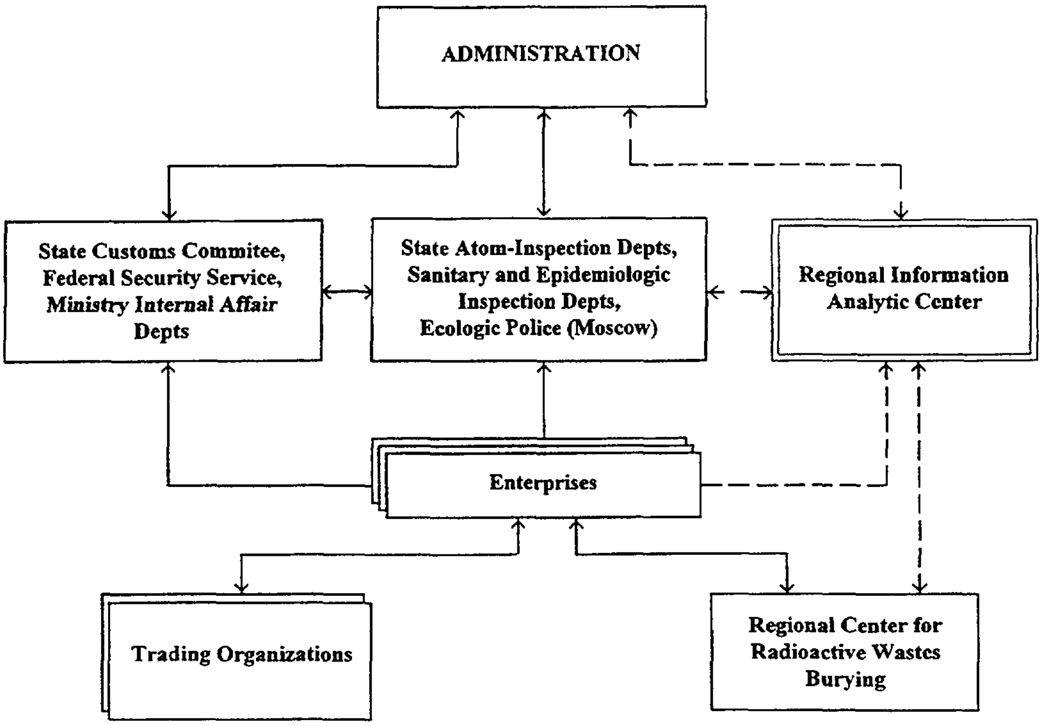

Fig.1. Structure of information relations.

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MANAGEMENT OF „ORPHAN" SOURCES

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Abstract

The experience has shown that most of the accidents with severe radiological consequences take place when radioactive sources were beyond the control system

In Argentina, the primary framework in radiological safety was established in the late fifties, with a non-prescriptive regulatory approach. For any application involving radioactive material, users must be authorised by the Authority, unless the application has demonstrated to be exempted. The licensees are responsible for ensuring protection against the risk associated with exposure to radiation, and for safety of radioactive sources. To obtain an authorisation, the applicant has to prove to the Authority knowledge and capability to carry on an application. Not only normal operation circumstances are considered, but every conceivable accidental situation

It has been shown the existence of radioactive sources not attributed to an authorised user or installation, and therefore outside of the primary control structure described above. These sources, from here on called „orphans", recognise several origins

The regulatory authority should necessary foresee mechanisms to afford early detection and management of these sources, before an undesired consequence arises. Up to some extent, the deployment of multiple and varied organisations or procedures, could be understood as a „defence in depth" concept, applied to the control

1. Introduction

In Argentina the use of radioactive materials in industrial, medical and research applications by more than 4000 registrants implies a large and heterogeneous number of radiation sources distributed within a very large territory. For its control, a primary framework of safety was established in the late fifties, with a non-prescriptive regulatory approach [1]. The regulatory system, on the basis of: standards, registration, authorisation, inspections and, even more, the ability of users to safely work with radioactive materials which are the essence of such framework.

However, experience has shown that most of the accidents with severe radiological consequences take place when radioactive sources were beyond the control system [2] [3] [4]. Fortunately, do not occur frequently. Nevertheless, the associated consequences have proved to be enormous, so when organising a country's regulatory system there is an urgent need to consider a response's capability to such unpredictable source of risk, in order to complement the primary framework mentioned. This paper gives the particular problems involved, and how the Argentine Nuclear Regulatory Authority takes care of them.

2. Framework for sources control

2.1. Control of sources within the regulatory system

The Nuclear Regulatory Authority (the Authority) is responsible to issue authorisations and control compliance to radiological and nuclear safety standards. [5] [6]. The purpose of the regulatory system is protection of people against exposure to ionising radiation and to assure control for safety of radiation sources. For any application involving radioactive material, users must be authorised by the Authority, unless the application has demonstrated to be exempted. The licensees are responsible for ensuring protection against the risk associated with exposure to radiation, and for safety of the practice and radioactive sources. To obtain an authorisation, the applicant has to prove to the Authority knowledge and capability to carry on an application with radioactive sources. Not only normal operation circumstances are considered, but every conceivable accidental situation. The Authority has the capability to perform independent safety assessment and inspections of the practices carried out with radioactive sources. For such purpose it is self-sufficient in specialist expertise in most matters, have its own calculation tools, laboratories, and monitoring equipment. There is a suitable inspection programme according to the risk represented by each practice [7]. This programme does not intend to substitute the licensee's responsibility on the safe performance of the practice and in accidents' prevention. It allows the Authority to obtain a critical and independent perspective of the safety culture, and to anticipate, thanks to a systematic screening, any possible safety problem. Every radioactive material user and facility in Argentina is duly registered. The Authority keeps records of users and installations, including safety assessments documentation and pre-operational studies. Besides, the files contain descriptions of safety systems, normal and accidental operational procedures, and each of the responsible user duties. Later, the files are completed with new safety assessments and the outstanding inspection findings.

Radioactive source records

Registration of the radioactive sources is relevant for control. The radionuclide, activity and physical characteristics of „permanent" (long half-life), and „transitory" (short half-life) sources are properly recorded. The regulatory control of unsealed sources used in medicine or industry is done indirectly by a careful bookkeeping. The activity of radioactive material delivered by the supplier and used in each practice, taking into account process looses and radioactive decay is recorded. In addition, every user is authorised up to a maximum activity for each radionuclide, in accordance with the practice for which he is licensed. In this way, the total inventory of radioactive material is controlled effectively. A substantial key for the safe control of radioactive sources is how the regulatory system keeps track of mobile sources (for instance gammagraphy equipment). Such sources, due to their permanent movable condition, have an additional risk: the chance to be lost. Besides the normal inventory records, the users must have an up-to-date movement record, where they register the locations where to the sources are transported, dates of dispatch and recover, and person responsible during the movements. All records are checked routinely during inspections, and at authorisation termination. This checks, allows the Authority to keep track of all radioactive sources, from practice introduction until final disposal.

Delivery of radioactive sources

The Argentine standards stipulate that producers, importers, and dealers of radioactive sources can only deliver radioactive materials to users authorised by the Authority. They should keep a radioactive material sales record where the customer must be identified. The Authority receives periodically copies of those files and crosschecks the information against the results of inspections to registrants.

To control the sources imported from abroad, the agreement with the Custom's Authority implies that no radioactive material is allowed to enter the country if the Authority has not corroborated the pertinent documentation. The Authority verifies sources description and identification, and if the receiver is authorised for type of radionuclide and activity, carrying on inspections when necessary.

The framework described applies to a safe practice using radioactive sources, and includes considerations on events that could arise during practices. Anyway, the possibility of occurrence abnormal situations must be limited if risk has to be kept low. Radioactive sources could escape control during an accident, giving up to a situation similar to the problems described later. Nevertheless, the Authority staff and users intervening in accidents has been properly trained for an effective response in such circumstances.

2.2. „Orphan“ radioactive sources.

International experiences have shown the existence of radioactive sources not attributed to an authorised user or installation, and therefore out of the primary control structure described above [2] [3] [4]. These sources, from here on called „orphans“, recognise several origins: Sources from pre-regulatory time's practices, stolen, lost, imported illegally, etc.

Regarding „pre-regulatory“ system sources, the presence, as „orphan“ sources will probably decrease with time, once an infrastructure as described is implemented and the means to detect and manage them are developed. On the other hand, the increment of applications of radioactive sources in industry and medicine might enlarge the number of users. Consequently, that could increment also the number of lost, stolen, and illegally entered to the country radiation sources.

The regulatory authority should necessary foresee mechanisms to afford early detection and management of these sources, before an undesired consequence arises. It should not be appropriate to consider as a success of a system established for control if an „orphan“ source is discovered due to the radiological consequences produced.

To organise such system, it is important to consider some common distinct characteristics, for instance:

- The uncertainty due to the wide spectrum of the radiation source types and activity used in different applications.
- The low efficiency for identification of radioactive sources by means of safety symbols, especially when they are out of their containers. Very few words or small symbols only know by specialist's make this safety indicator fail in small-in-size sealed sources. Very old radioactive sealed sources or unsealed ones could have no radiological indications and only identified with appropriate monitoring equipment.
- Contrary to what happens with sources within the primary control system (the radiation source been handle by a trained person), people exposed to „orphan“ sources are unaware of the implied danger and do not know how to deal with it.
- There are not typical scenarios for a „orphan“ radioactive source showing up, however the international experience could give some good clues.
- Sealed sources are usually a shining piece of metal, and catch people's attention. Unsealed or broken sources usually have chemical compounds easy to disperse, leading to external and internal contamination.
- The time delays in showing up of first consequences, that could lead to suspicion of radiological damage, are usually large. Experience has shown has happened even for sources with significant activity, when compared to other equivalent dangers to whom people could be exposed (toxic substances or chemicals for instance). This could lead to a large number of people affected.

Considering these characteristics, the control system, should include mechanisms to detect „orphan“ sources. It is very important for safety, to inform people and organisations about the potential existence of „uncontrolled“ radioactive sources. The spreading of information shall not produce unnecessary alarm but sufficient warning. The Argentine Authority is developing a programme that will include publications distributed among many public service organisations, public libraries, schools, and other similar organisations.

It is also important, to whom the public should address as soon there is suspected material. Security forces, firemen, hospitals are usually the first organisations alerted on the existence of such elements. The Authority has organised training of personnel from those organisations in order to qualify them for radiological emergencies and first protective actions.

International border paths, airports, and ports are usual ways of entrance of radioactive material, in some occasion „orphan“ sources. The Gendarmerie (border's army) has teams and monitoring equipment which is brought in to confirm the presence of radioactive material. In addition, the Custom Authority, while carrying on the administrative control to detect illegal entering and other custom's felonies, reports any suspected material to the Regulatory Authority.

Within the country borders, the Federal Police is the organisation with the most comprehensive structure for detecting „orphan“ sources. The Authority has developed intensive plans for training personnel in monitoring techniques and intervention procedures. Several arm forces services have also capability to identify radioactive sources.

The domestic and international experience have demonstrated that radioactive sources, many times, finish up in some particular places like scrap yards, smelting works, industrial waste treatment plants, etc. In the country some facilities have fix-portal or portable radiation detectors for incoming materials and report any activity indication to the Authority. In view of the good results obtained, a compulsory imposition of these detectors is under consideration.

Once an „orphan“ source is detected and the situation has been reported, a fast response must be assured. For this purpose, the Authority has a full time Radiological Emergency Intervention Group. The group is operative at all times, ready to act upon requests from within the Authority or from outside. Each shift of the Intervention team is staffed and run by highly qualified personnel trained in emergency response matters and has appropriated equipment and materials to carry on its duty. „Orphan“ radioactive sources must be put in safe conditions and immediately disposed as radioactive waste. For people potentially affected with radiological consequences, there are hospitals ready to take care of them after first aid is given.

Up to some extent, the deployment of multiple and varied organisations or procedures, could be understood as a „defence in depth“ concept, applied to the control infrastructure.

3. Conclusions

The organisation of the Argentine regulatory control structure for radioactive sources is based on a combination of::

- Knowledgeable users well trained;
- An independent institution that establishes safety standards authorises users and installations and carries on inspections.

However, this regulatory structure is valid only with radioactive sources under control, taking into account normal and conceivable accidental situations.

International experience has shown that there are radioactive sources not related to an authorised user or installation, and consequently are out of the basic control scheme. They are: „orphan“ sources.

For „orphan“ sources, the regulatory organisation should consider special mechanisms or procedures to detect them, and keep out of danger the people involved, well before the first radiological consequences could arise.

Prevention measures for „orphan“ radioactive sources must be considered as a necessary complement to a primary control system. In Argentina the Nuclear Regulatory Authority have agreed with different security, civil service and health organisations, procedures to promote early detection and response of „orphan“ sources in order to prevent or minimise radiological consequences. The experience shows that the overall risk is properly kept low with this practical criterion.

The inclusion in the control framework of additional organisations, besides those specially involved by law with the use of radioactive materials (users and regulatory authority), extends the „defence in depth" concept to a countrywide infrastructure for control.

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DEVELOPING AND IMPLEMENTING SAFETY CULTURE IN THE USES OF RADIATION SOURCES

XA9848199

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Abstract

This paper presents an approach to develop and implement safety culture in the uses of radiation sources in medicine, industry, agriculture, research and teaching, and makes reference to the experience gained by the industries where that culture has been developed and improved, i.e. the nuclear industry.

Suggestions to assist progress toward safety culture are here described for regulators, organisations using those sources, and professional associations. Even though emphasis is given to small organisations or teams of workers, this approach may be also useful to greater organisations like industrial irradiation companies or governmental research laboratories. In each case, parties being the principal focus of the learning process toward a progressive safety culture should be identified.

1. Introduction

The International Nuclear Safety Advisory Group (INSAG) [1] described two general components of safety culture: *a framework in the organisations that is created by management, and an attitude of staff at all levels in responding to and benefiting from that framework.*

The development of those components is of mayor importance regarding the widespread uses of radiation sources in medicine, industry, agriculture, research and teaching. Safety culture and feedback from experience are of critical significance for the prevention of radiological accidents involving these sources [2-4], and are helpful to deal with the problem of orphan radioactive sources [5].

Orphan radioactive sources are those sources out of control of the user or the Regulatory Body. Those sources may have been misplaced, discarded, lost, or stolen, and in some cases the Regulatory Body may have no notice about them until an abnormal situation occur [6].

A well developed and implemented safety culture is essential. Inadequate training of the staff, mishandling of sources, poorly defined procedures and lack of a questioning attitude, are some of the most important lessons learned from accidents.

2. Remarks on safety culture

Industrial radiography teams or companies, nuclear medicine services, industrial plants using few industrial gauges, are examples of small organisations whose staff have only the necessary technical knowledge to manipulate the sources. Irradiation plants, nuclear pharmacies, hospitals, are in turn examples of greater organisations with skilled professional and technical staff working under well established operational procedures.

A number of countries have only small sized organisations or teams of workers using radiation sources. Translation to them of the practical experience in safety culture gained in the nuclear industry [1,7,8], requires careful consideration of the particular social and economical context which they work in.

The small size of those organisations and their unfavourable working environment may not guarantee sound internal discussions or appropriate learning conditions on safety issues.

Inappropriate attitudes at both individual and staff level may compromise their commitment on safety culture development and implementing.
In these cases, as safety culture recommendations alone may not convince individuals to adopt the behaviour needed, social mechanisms will have to be set in place to promote individual commitment [9].
Universities and professional boards may promote learning process to assist safety culture development, and ethics review committees in medicine should address safety issues to certify standard quality in medical treatments using radiation sources.
Discussion meetings, technical refresh courses, and periodic update communications in professional boards and associations, should play for the individuals working in small organisations, the role assigned by safety culture to the upper-down and bottom-up communications in large organisations.
Concepts like organisational culture, unity of purpose among employees, behaviour of employees toward each other and toward others external to the organisation, should be adapted and made suitable to the size, diversity and environment of small or even unipersonnel organisations.

3. Social mechanisms

In order to help to overcome those drawbacks on safety issues of small organisations, the regulatory body should focus its attention on the unions or associations formed by them. As memberships of the unions, the organisations are parts of an extended network with similar interests and difficulties.
Each of these networks may be considered as the subject in the concepts of vision, mission, goals and values of safety culture. The sense of accountability of the organisations in the network would help to promote safety improvement nation-wide.
Institutions engaged in research & development activities in medical and industrial uses of radiation sources, should support safety culture development and implementation in these networks. Working jointly with regulators, these institutions should provide sufficient scientific and technological context for progressive updating of the staff of small organisations.
This approach is being implemented successfully in Argentina, and these are some examples:

1. The National Atomic Energy Commission and the Ministry of Public Health working together with professional associations of radiotherapists and phycisists, conduct since the sixties programs aimed at promoting medical excellence and radiological safety in teletherapy
2. Annual nation-wide intercomparisons of dosimetric methods in teletherapy are being launched in that context.
3. Discussion meetings with organisations working in industrial gammagraphy, with nuclear medicine professional associations, etc., are being conducted periodically by the Nuclear Regulatory Authority in order to promote safety culture in those practices.

4. Stages of development of safety culture

National policies are a necessity to boost the development and implementation of radiological safety and security in the organisations responsible for the uses of radiation sources. In particular, in the case of small organisations, teaching institutions and professional associations should occupy significant roles to support learning processes.
Management and technical staff responsibilities in these organisations usually are not clearly defined. Highly skilled professionals or technicians are the exception, and in general the

technical staff have only the necessary knowledge to deal with their work. These organisations do not facilitate training and periodical retraining of their staff, and they lack of a policy to disseminate information on safety issues.

Understanding of safety culture and self diagnosis of its stage of development may be difficult in their environment of economical urgencies, small number of employees, and other adverse constraints. Professional associations should help organisations and individuals in their understanding of safety issues, and should provide an appropriate environment for „horizontal" communications between them.

The following classification of stages of development of safety culture in small organisations, is descriptive and not rigid. At any time they may exhibit a combination of the following main characteristics of the stages.

Stage i - Safety issues are not fully addressed by the organisation.
Stage ii - Safety issues are addressed mainly to comply with regulations or as a formality.
Stage iii - Good safety performance becomes an organisational and individual goal.

5. Actions toward safety culture

The suggestions in Table I are examples of some actions aimed at assisting organisations in their progress toward higher stages of development of safety culture.

They are directed to managers, owners, professionals, or anyone occupying top positions at an organisational structure, and are listed for stages i and ii previously mentioned.

Table I - Suggestions to assist progress toward safety culture in the uses of radiation sources

Stages	*Suggestions*
i to ii	*Require support from other organisations (professional associations, regulators) to review or formulate safety policy, and communicate that action to the staff.*
	establish safety training of the managerial level and the staff
	facilitate employees participation in the activities of professional associations.
	introduce regular review of safety and seek for employee's suggestions in order to identify areas of improvement, with emphasis on safety and security of spent sources.
	make employees aware of safety issues as part of quality performance.
ii to iii	*make employees aware of strategic goals that relate quality and safety to long-term profits or redits.*
	make employees aware of other organisations who have successfully improved their safety performance, to demonstrate that achievement is possible.
	Review safety performance and make employees aware that safety is not only a technical issue. Promote a questioning attitude to prevent the problem of orphan sources
	Facilitate cross communications with similar organisations and start collaborative work with regulators.

6. Errors as a learning opportunity

Employees at small organisations should be encouraged to report human errors during operations. Even though economical difficulties normally experienced by these organisations compromise their commitment on safety culture, manager should promote employee participation in professional boards and associations to discuss and learn lessons about their experience.

Special attention should be paid to cognitive mechanisms as they determine the extent to which questioning attitude is retained during operations [7]. When the individual is experienced the operations become automated to such an extent that they no longer require conscious control.

7. The role of the Regulatory Body

The Regulatory Body should conduct a review of the factors in the national culture that may have significative influence in the developing and implementing of safety culture, and should promote programs aimed at assisting small organisations in the cultural changes their staff must undergo.

It should also consider the following points:

- retaining its role as driving force toward safety culture in the uses of radiation sources,
- increasing its attention on safety issues during compliance monitoring at small organisations,
- following up any radioactive source whose safety is not fully guaranteed, or is not longer in use,
- implementing a sound enforcement program helpful to prevent radioactive sources ending up in the public domain,
- disseminating among the licensees information on enforcement actions and penalties.

The Nuclear Regulatory Authority in Argentina has an extensive experience gained in the control of radiation sources, and as described in Section III it has successfully promoted actions toward safety culture in the small organisations. It has also implemented monitoring compliance [10] and enforcement [11] programs whose practical guidelines are aimed at the prevention of radiological accidents. Special attention is paid in these programs to indicators of problems of orphan or spent sources, and immediate actions are taken to provide for their safety and security.

8. Conclusions

An approach based on actions by Regulatory Bodies and by some social mechanisms may be helpful to facilitate the implementation of safety culture in small sized organisations working with radiation sources. In particular, this approach would be useful to prevent radiological accidents and to deal with orphan radioactive sources.

These actions of social mechanisms, according to national peculiarities, rest on the role the professional boards and associations should play. They should provide small sized organisations and individuals with a suitable environment for cross communications, technical updating and learning on safety issues.

Some actions described here may help the organisations to achieve higher stages of development of safety culture. A questioning attitude of the staff may prevent the problem of orphan sources.

The Regulatory Bodies should probably retain during a long time a leading role promoting safety culture, and should also have monitoring compliance and enforcement programs aimed at detecting and securing spent and orphan sources. They should also consider disseminating information on enforcement actions to licensees.

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LEARNING FROM OPERATIONAL EXPERIENCE

(Technical Session 4)

AN OVERVIEW OF INDUSTRIAL RADIOGRAPHY ACCIDENTS IN INDIA DURING THE PERIOD 1987-1997

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Abstract

Use of gamma radiation sources for non-destructive testing of welds, castings and vital components in several industries in India has recorded a steep rise in the last three decades There are over 1000 industrial gamma radiography exposure devices (IGRED) in over 400 institutions in the country Most of these employ Co-60 and Ir-192 gamma sources. In spite of regulatory control and procedures there have been accidents with the IGREDs resulting in significant radiation exposures and in some cases, injuries to members of public and radiography personnel. This paper analyses the accidents which occurred in India during the ten year period of 1987-1997, management of such accidents, steps taken to avoid recurrence of these accidents based on the lessons learnt.

1. INTRODUCTION

NDT based on radiation technique is an indispensable tool and is widely used for inspection and quality control of vital components in various industries. Facilities for induction of trained manpower, ready availability of radiography equipment and sources and awareness of quality assurance requirements have added to the growth of radiation technique of NDT. There are about 400 institutions spread among private and public sector undertakings engaged in industrial gamma radiography throughout the country. Imported remote operated equipment in addition to indigenously fabricated equipments form the major support for use of iridium-192 and cobalt-60 sources. Even though the radiation safety record in industrial applications has been good, there have been some accidents/incidents in different applications. A radiation accident is different from accidents in other fields as the effects of radiation are not immediately felt. Because of this insidious nature, a radiation accident can lead to very serious consequences. The likelihood of occurrence of an accident in industrial radiography is fairly high, because majority of the radiography work is carried out in public domain, such as construction sites, workshop areas and inaccessible locations. The source activities used in industrial radiography are quite high, hence in the event of an accident, there is the possibility of very high doses, even up to lethal doses in certain cases. Though there are nearly 1000 radiography sources used in about 500 radiography sites in India, the accident rate is quite low and no fatal cases have been reported in industrial radiography field. This paper outlines and analyses the accidents in India in the last decade.

2 ANALYSIS OF ACCIDENTS

There have been 33 radiation accidents in this field during 1987-97 in India. Although most of them were of minor nature, a few of them resulted in radiation injuries to the exposed individuals. As far as a gamma radiography source is concerned, an accident can occur even when the source is not in use. The analysis shows that accidents have occurred in all the three main stages namely, storage, use and transport of radiography sources. Table 1 lists some of accidents which occurred in India during 1987-97

Table-1 : Some Industrial Radiography Accidents in India During 1987-97

Period		Source / Equipment and Incident	Remark
Sep	1987	292 GBq iridium-192 source assembly in lead pot stolen from storage room	Recovered next day
Dec	1987	65 GBq iridium-192 source assembly in lead pot stolen from site	Recovered after 3 months Found buried under ground
May.	1988	1.07 TBq iridium-192, TechOps-660 source housing. Guide tube was found damaged, as a heavy object had fallen on it during use.	It was rectified and the source assembly was brought back into its housing
Jun	1988	74 GBq iridium-192 source assembly was stolen along with lead pot from a site It was left unattended	Source assembly was recovered after three days from the site
Jan	1989	148 GBq iridium-192 source assembly attached to the manipulator rod was stolen during radiography operation from the site	It was traced after five days from a scrap dealer's shop Three persons were sent for CA test. Whole body dose . 50 - 260 mGy
Mar	1989	1.41 TBq iridium-192, Inditron-520 source housing. The source assembly got detached and remained inside the guide tube	It was retrieved into its housing
Sep.	1989	880 GBq iridium-192, TechOps-660 source housing. The source assembly got stuck in the guide tube. The operator had difficulty in retrieving the assembly He disconnected the source assembly and shook it violently with both hands.	Three fingers on the left hand and two fingers on the right hand had got exposed The estimated dose to fingers was 8 8 Gy
Feb	1990	925 GBq iridium-192, TechOps-660 source housing. The source assembly got detached due to improper coupling and it remained in the guide tube	It was retrieved back into its housing
Feb	1991	1 7 TBq iridium-192, Century SA source housing The source assembly got stuck in the housing	Plunger arms of the lock were found broken & the pieces were obstructing the source assembly movement It was rectified
Sep	1991	60 GBq iridium-192, TechOps-660 source housing The source housing was stolen from the storage room	It was found lying in a ditch outside the fence of the factory

Period		Source / Equipment and Incident	Remark
Feb.	1993	85.1 GBq iridium-192 source assembly in a lead pot fell into sea, 90 m depth during use on an off-shore platform.	Not recovered, abandoned
May.	1993	267.8 GBq cobalt-60 source assembly got detached. It fell inside the enclosure.	It was picked up with CV tongs and put back into its housing.
Oct.	1993	1.6 TBq iridium-192, TechOps-660 source housing. The source housing was booked in brake van of a train. It was lost.	Not recovered.
Jan.	1994	1.67 TBq iridium-192, TechOps-660 source housing. The source assembly got stuck. An untrained person operated the source housing.	The untrained person got injury in his right hand thumb, index & middle fingers. CA test dose estimated was 0.38 Gy. Exposure to hand could be much higher
May.	1996	40 GBq iridium-192, TechOps-660 source housing. The source housing was stolen from the storage room.	It was recovered from a scrap dealer's shop.
Oct.	1996	1.0 TBq iridium-192, Teletron source housing. The source assembly got detached and fell from a height of 30 m and broke in two pieces.	Broken pieces were recovered and put back into the housing.
Jan.	1997	41 GBq iridium-192, Spec-2T source housing. The source housing was packed in a steel box and it was lost during transport in brake van of a train.	Recovered from the railway yard after two months.
Aug.	1997	592 GBq iridium-192, Roli-1 source housing. The source housing kept in storage room was washed away in flood.	Not recovered.
Sep.	1997	296 GBq iridium-192, Gammarid source housing. The source assembly got detached and got stuck at the exposure head.	It was put back into a lead pot.
Sep.	1997	2.07 TBq cobalt-60, TechOps-676 source housing. The source assembly got detached and remained in the guide tube inside a radiography enclosure.	It was retrieved back into its housing.

Among the possible accidents, loss of radiography source needs to be viewed seriously, because the source can reach the hands of members of public who are totally ignorant of the hazards associated with radiation sources. The lost source, if not traced quickly, can lead to very severe consequences. There were 16 cases of missing radiography source/equipment during 1987-97. Out of these, 8 sources could be traced. Out of these, 3 were cases of loss due to improper transport and the rest due to improper storage. One source assembly had fallen into the sea during use and in another case, the equipment along with source was washed away during flash flood. In all those cases where the source could not be traced, through extensive search and interrogation, prior to abandoning search operations, it was confirmed that the source had not reached the hands of members of the public or was not likely to result in significant radiation doses to any body. In all these cases, the chances of tracing the source became dim mainly due to delay in noticing / reporting the loss. From the analysis, it is very clear that improper storage or improper transport coupled with carelessness of the radiography personnel are the main reasons for the source loss. There were 17 such cases of accidents which occurred during 1987-97 while the radiography sources were in use.

Accidents and consequent radiation exposure / injury during use happen mainly because of the following reasons :

a) handling of sources by untrained persons,
b) use of defective equipment and/or its failure,
c) failure to use radiation survey meter.

In three incidents, some untrained operators/radiographers received radiation injuries. Fortunately, their whole body doses were not significantly high. However, the radiation injuries received by them were serious and needed prolonged treatment. As the activity of the sources used in these source housings are generally high, even a single accidental exposure can result in radiation injuries.

There were 13 cases of accidents involving decoupling/source stuck up during 1987-1997. In one case, the source assembly came out of the equipment, fell 30 metres below the level of operation and broke in two parts. In most of the cases, either the source housing was handled by uncertified operator or the certified radiographer had failed to verify the physical integrity of the coupling before driving the source out of the housing. The design of most of the remote operated source housings is such that the source cannot be pushed out of the source housing without proper coupling between the source assembly/pigtail and the drive cable. But, this safety feature is likely to fail either due to wear and tear or due to poor maintenance. Many such accidents could be easily avoided, if the personnel adopted proper work practice.

3. CONCLUSIONS

Radiation accidents, like other accidents do not occur but are caused. An analysis of these accidents clearly indicates that human error is the major cause for these accidents. Accidents occur mainly due to not adopting proper work practice and violating of safety rules at various stages. Proper maintenance of the equipment and accessories would not only ensure prolonged trouble-free operation, but would also minimize chances of occurrence of detachment of source assemblies. Based on our experience and analysis of accidents, some models of IGREDs were withdrawn from use and replaced by safer versions. In spite of all precautions and procedures, should the accident occur, early recognition and action would mitigate the consequences of the accident and minimize further damage. Utilization of trained personnel is very important for minimizing chances of accidents. Radiation safety depends crucially on the operators being aware of proper working procedure and this is achieved through appropriate training. Thus the main concern of Regulatory Authority is the training and knowledge of the authorised personnel. Periodic refresher courses are conducted for trained personnel, so as to keep them in constant touch with the subject and also to update their knowledge. The Radiological Physics and Advisory Division of Bhabha Atomic Research Centre is associated in the conduct and coordination of radiation safety training programmes for users of radiation sources for more than 35 years.

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UNUSUAL EVENTS REGARDING LOSSES AND FINDS OF RADIOACTIVE MATERIALS IN GERMANY IN THE YEARS 1991 TO 1997

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Abstract

In Germany safety related events in the use and transportation of radioactive materials as well as in the operation of accelerators are registered completely. Registration and licensing of radioactive sources and the system of notification of the authorities of unusual events are presented. The analysis of these events demonstrates their causation and allows the conclusion on avoidable errors. Especially events like losses and theft of radioactive materials on the one hand and the finds of such sources in public domain on the other hand are analysed in detail. Conclusions (lessons learned) are drawn.

1. Registration, Licensing, Notification of the authorities

Basically three legal regulations exist in Germany to ensure the radiation protection and safety in the use of radioactive materials:

- Atomic Energy Act (AtG)
- Ordinance on the Protection against Damage and Injuries caused by Ionising Radiation (Radiological Protection Ordinance - StrlSchV)
- X-Ray Ordinance (RöV)

The Federal Ministry for Environment, Nature Conservation and Reactor Safety is responsible for the enforcement of the Atomic Energy Act as well as the Radiation Protection Ordinance. The enforcement of the X-Ray Ordinance is the duty of the Federal Ministry for Work and Social Affairs. According to the federal system in Germany Local Authorities of the Länder are responsible for the registration and licensing of use of radioactive materials. The Local Authorities have to be immediately informed about incidents, accidents and other safety-related events. Furthermore this law prescribes that the one who finds and takes radioactive material has to report it to the supervisory authority as soon as one gets knowledge about the radioactivity.

To inform relevant Federal Authorities and, if necessary, authorities of other Länder and to ensure feedback and lessons learned from the unusual event, an agreement about the report on unusual events was entered into between the Federal Ministry and the Local Authorities already in 1981. First of all it concerns unusual events without any significant radiological consequence after the first assessment. The registration and analysis of events deviating from normal operation or of near-misses is important to recognise potential exposures already in the initial phase and, if necessary, to initiate measures at an early stage. Especially losses and finds of radioactive sources are to be considered here.

2. Causation analysis referring to losses and finds

In the years 1991 to 1997 the Local Authorities responsible for licensing and supervision reported 490 unusual events referring to the use and transportation of radioactive materials as well as to the operation of accelerators in Germany. 22% of these events happened in the field of medical use of radioactive materials, 40% in the field of industrial use, and 38% were events in the public domain including transportation and mainly finds of

radioactive materials. Assessing the events it should be taken into consideration that one event can involve more than one radiation source.
In the considered time period the total number of reported events of loss or find of radioactive materials in Germany was 234 (145 finds and 89 losses). An overview of the events in each year is given in Figure 1.

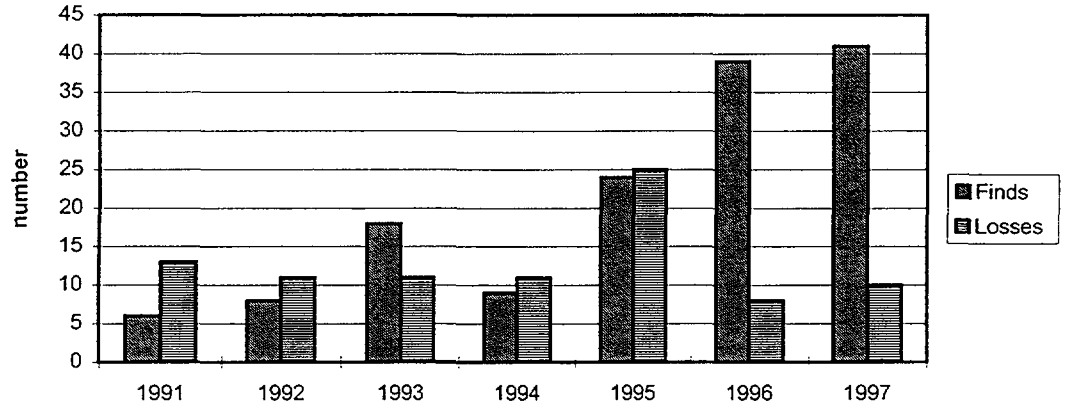

Fig. 1: Numbers of find and loss of radioactive materials in Germany 1991-1997

In the years 1995-1997 the number of events of find of radioactive materials had clearly increased. The number of events of loss of radioactive materials was conspicuously high in 1995.
The main causes of finds are summarised below with the frequency of their occurrence:
- *Throwing away instead of proper disposing of radioactive materials in normal operation by the users, licensees or registrants (48 events)*

For instance in an incinerating plant a bag of radioactive contaminated waste was found. This waste was given into domestic rubbish by a cleaner who was not adequate instructed. Similar cases also occurred in scrap yards and in several other places of public domain.
- *Failure to properly dispose of radioactive materials during or after bankruptcy, decommissioning or remediation of the sites or facilities (34 events)*

For instance decommissioned devices containing radioactive materials or sources no longer in use were stored and than they were forgotten. In other cases workers stored the radioactive materials after decommissioning at home and the new owner of the apartment or building found it.
- *Unauthorized acquisition or selling of radioactive materials or devices containing radioactive sources and illegal import or export (34 events)*

In few cases during commissioning of a device the new owner noticed the radiation sign informing about the contained radioactive source. They had not got any information about it by the supplier or former owner. In other cases at frontier clearance some lorries with shipments containing radioactive materials (mostly ores or scrap containing radioactive materials) were detected. The drivers did not have any licence for transportation and import or export of the radioactive materials.
- *Finds of radioactive materials at abandoned military facilities (18 events)*

Finds at such areas was a special issue in the new East German Länder.
- *Finds of stolen sources (6 events)*
- *Misdirecting during transportation and unknown causes (5 events).*

Figure 2 shows the frequency of the events related to the causes for each year between 1991 and 1997. The clearly increase of the finds of radioactive materials in 1995, 1996 and 1997, mentioned above, is the result of the increased frequency of failure to dispose the waste during decommissioning of devices, facilities and sites (1995, 1996 and 1997), of the increased number of finds of radioactive materials in areas previously used by armed forces (1995, 1996), increased number of finds due to illegal acquisition or selling of devices or materials containing radioactive materials (1996 and 1997) and especially in 1997 as a result of increased number of events of inadmissible waste disposal.

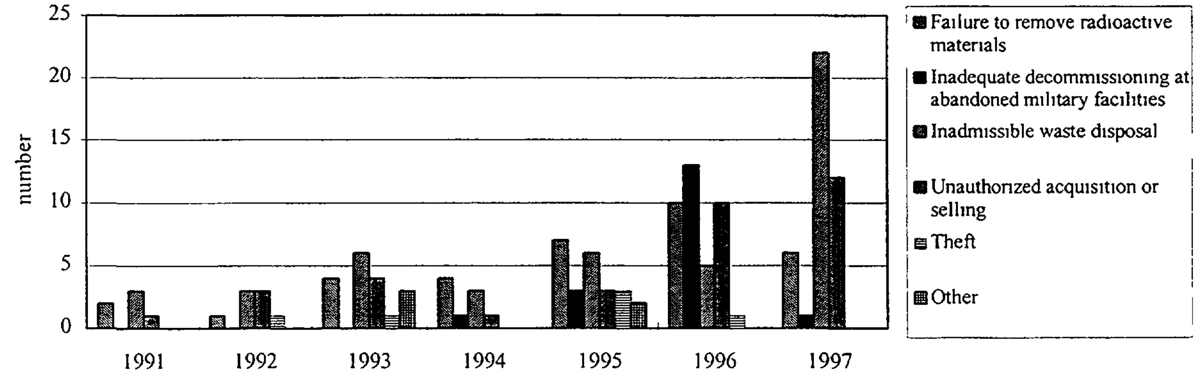

Fig. 2 : Causes of events of finds of radioactive materials in Germany 1991-1997

The losses of radioactive materials were caused from 1991 to 1997 by (see Fig. 3):

- In 25 cases radioactive materials were stolen. 6 events occurred in schools. In 4 cases presumably the car or the container which the radioactive materials were stored in together with money were of more interest for the thieves than the sources. In 5 cases the stolen sources could be found and taken in.
- 20 events occurred because of insufficient control of the completeness of the number of sources during storage as well as immediately after use.
- 12 cases were the result of inadmissible waste disposal. 8 events occurred in hospitals. Radioactive contaminated waste and some radiation sources were inadvertently given to incineration plants.
- 10 times wear and tear or breakdown were the reason for losses of radioactive materials. In 3 cases sources were lost because the source equipment was defect. In 2 cases the probe of device during exploration of soil tore or break off. The sources could not be salvaged.
- 8 events were the result of a lack of disposal of devices or sources no longer in use. They were placed in storage and got out of control. After a special time nobody knew where they were.
- 14 events were caused by fire, illegal selling or occurred during transportation. Only in 3 cases the causes are not known.

Summarising the results of the analysis of the 234 events it can be established that 26 % were caused by inadmissible waste disposal, 18 % by failure to dispose during decommissioning, 14 % by unauthorised acquisition, selling or import or export, 13 % by theft, 9 % by insufficient control of completeness, 8 % by insufficient clearance of areas previously used by armed forces and likewise 8 % by other reasons. Only 4% of all notified events of find and loss were a result of breakdown .

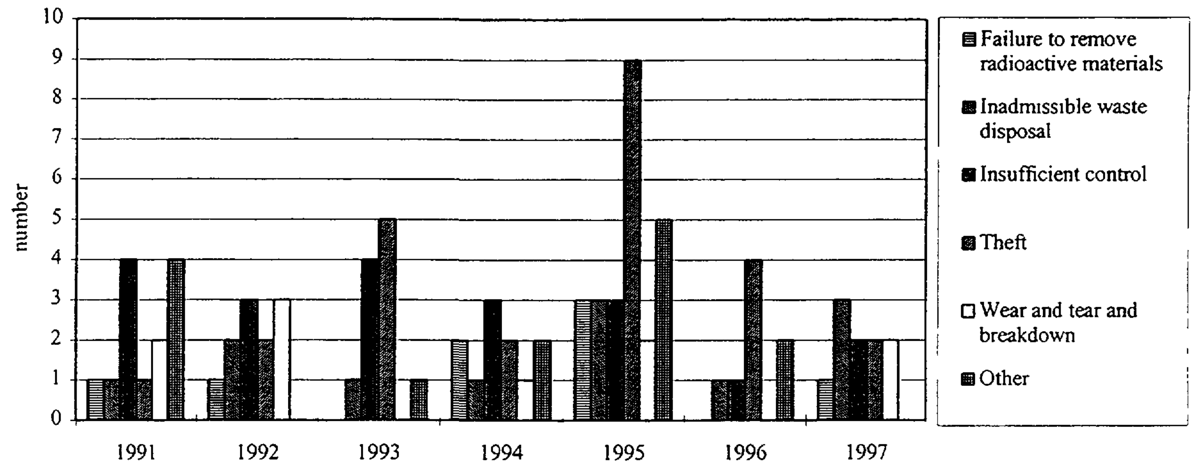

Fig. 3: Causes of events of loss of radioactive materials in Germany 1991-1997

Fortunately most people involved in events got only a very low radiation exposure due to the found radioactive materials because of the low activities or the shielding container the sources were in. But in one case it was estimated that several employees of a research institute were exposed up to 9 mSv/y for some years, resulting from a storage of Ra-226 sources in a safe. The existence of this safe in the workroom was unknown.

3. Conclusions

Although the exposures of people involved in unusual events have been very low, there is a higher potential danger if the handling of radioactive materials found or lost is improper. This is particularly true for sources with activities of several GBq.

As already mentioned, 96 % of losses and finds were caused by human errors. Significant deviations from local working rules, working instructions and other requirements occurred. The quality assurance programs at facilities handling low activities were apparently weak. Partly the training or instruction of workers was not adequate or their consciousness of responsibility wasn't marked enough. On the other hand there seems to be in general a failure in connection with decommissioning of devices, facilities or sites which require little attention and infrequent maintenance and tend to be forgotten, for instance the industrial gauges. 10 events in industrial gauges were caused by failure properly to dispose during decommissioning of devices or sites. Just as in hospitals 8 times the lack of proper disposal of the old Ra-226 sources no longer in use led to sources got out of control.

One of the lessons learned in use of high activity sources that were at the end of use is in compliance with the suggestion of the IAEA: „For an organisation using only sealed sources, the Regulatory Authorisation may wish to require, prior to authorising the activity, that an applicant makes arrangements for the return of sealed sources to the supplier or for disposal by a waste contractor at the time the sealed sources are initially purchased. ... In order to ensure timely decommissioning of major facilities the Regulatory Authority may consider the need for the licensee or registrant to provide financial assurance of the ability to fund the decommissioning."[1]

For registration of sources which are delivered the identification numbers should be filed together with the license number in databases at the Regulatory Authority. So it would be possible to find the licensee in a short time when a source is found.

The implementation of radiation measurements at entrance of scrap yards was successful in detection of radioactive materials in scrap shipments in order to prevent such accidents occurred in Goiania [2] or Taiwan [3].

Notification of the Regulatory Authorities about a lost source has to be done by the licensee or registrant as soon as possible to increase the chance to investigate the event successful. For instance a stolen industrial radiography device could be taken in within one day because of a fast notification of the event.

Likewise a liberal report culture is necessary within the sites or institutions. Competition for jobs or fears of harassment or intimidation must not have any influence to notification.

There must be full reporting of events and dissemination of the lessons learned to all relevant groups, particularly the users of radiation materials themselves. An aid to fulfil this aim is the use of a clear and well-structured form for registration of the events to ensure that all relevant data are reported.

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RADIATION ACCIDENT IN VIET NAM

XA9848202

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Abstract

In November 1992 a Vietnamese research physicist was working with a microtron accelerator when he received a radiation overexposure that required the subsequent amputation of his right hand. A team from the International Atomic Energy Agency visited Hanoi in March 1993 to carry out an investigation. It was concluded that the accident occurred primarily due to a lack of safety systems although the lack of both written procedures and training in basic radiation safety were also major contributors.

1. Introduction

The microtron accelerator, model MT-17, is a prototype design that was donated to the Institute of Nuclear Physics, Hanoi, by the Soviet Union in 1982. The accelerator, which is capable of producing either photon or neutron radiation, is housed in a dedicated shielded room with a maze entrance. The walls of the room are reported as being 1.4 m thick concrete of unknown density. Access into the room is through a hinged steel door (approximately 2 mm thick). Inside the room, the tungsten target is surrounded by localised shielding consisting of an open topped wooden box lined with lead and paraffin wax. The accelerator control console is situated in a separate room that is located some distance from the maze entrance, along a meandering corridor.

In the normal course of events one of the researchers would manually position the sample for irradiation in front of the target and then report to the control room, from where the machine would be energised by the operators. The irradiation time is determined empirically as there are no facilities for monitoring the dose to the sample during the exposure. After irradiation the machine would be stopped and the sample manually removed and analysed by gamma spectroscopy or other appropriate methods.

2. Radiation safety at the institute

Prior to the accident, radiation safety had not been formally addressed, no radiation protection officer had been appointed and there were no local rules. The scientists were mainly experienced post doctoral researchers but they had received no formal training in radiological protection. Routine radiation monitoring was not carried out. The total inventory of portable radiation monitoring equipment was two quartz fibre electrometers and one end-windowed geiger tube with a rate meter scaled in counts-per-second (cps). A fixed position geiger tube was also installed in the maze entrance, and this was connected to a rate meter (also in cps) in the control room. None of the equipment had been calibrated or tested. There were no safety devices inside the accelerator room to warn persons of the accelerator status, nor was there a search-and-lock-up system or any door interlocks. Prior to switching on the machine, the operators relied on word of mouth that the room was clear of personnel. The only parts of the safety system that were operational were two warning lights that were illuminated when the electron beam current was switched on. One of the lights was situated outside the maze entrance and the other in the corridor leading to the control room. At the time of the investigation the broken remains of a siren and warning light were visible inside the accelerator room. It was reported that although regular preventative maintenance was carried out on the accelerator there were no similar provisions for the associated safety systems.

To place this accident in context, it has to be realised that the use of radiation in Vietnam is controlled by the 1988 Safety Regulations for Ionising Radiations. However, at the time of the accident these regulations were not being enforced because the national competent authority, the Vietnam National Atomic Energy Commission (VINATOM), had no suitably trained inspectors

3. The accident

At the time of the accident the research group was carrying out a series of activation experiments that required samples of gold ore to be irradiated with high energy X-radiation. After positioning the sample close to the tungsten target the physicist and his assistant left the accelerator room and walked towards the control room. When they were halfway there the physicist asked his assistant to get him some soap and he turned around as if he was heading towards the sink in the courtyard to wash his hands. On the way to collect the soap the assistant had to pass close to the control room and told the operators that the machine could be switched on.

In the meantime the physicist decided that he was not satisfied with the positioning of the sample so he re-entered the accelerator room and used some wax blocks to adjust its position. Whilst doing this his hands would have been a few centimetres from the X-ray target. He was not aware of the accelerator being energised because the distinctive buzzing noise of the magnetron could not be heard above the high ambient sound levels in the room.

After collecting the soap the assistant proceeded to the courtyard where she expected to see the physicist. Being unable to find him she rushed to the control room to stop the accelerator, which had been operating at 15 MeV, 6 μA for an estimated 2-4 minutes.

The physicist was eventually found in the maze entrance and was informed that the accelerator had been switched on, possibly whilst he had been in the room. He thought that his hands may have become activated if they had been irradiated so he went to the measurement room where they were checked on the gamma spectrometer. Within 30 seconds a well defined peak at 511 keV was apparent, presumably from activation products in the tissue and bone of his hands, but the extent of his exposure was not appreciated

4. After the accident

During the evening of the accident the physicist remembers that his hands began to feel 'strange', but as he had rheumatoid arthritis he did not link this with the incident earlier in the day. Over the next few days he worked as normal. Ten days after the accident he reported to the medical centre at the Institute for his annual medical and the palms of both hands showed signs of dry desquamation and his blood pressure was slightly higher than normal. The physicist told the doctor that the problem with his hands may be due to radiation exposure, but the doctor thought that he had a vitamin deficiency and recommended that he saw a dermatologist. The next day the physicist's hands were beginning to swell and he went to the general hospital in Hanoi. The accident with the accelerator was mentioned, but at this stage it was not confirmed as being the cause of his injuries and he returned home. Over the next two weeks his hands showed signs of increasing erythema and pronounced oedema. On day 24 he approached a specialised burns hospital and was admitted immediately.

The competent authorities were informed of the accident and in March 1993 they requested assistance from IAEA. A doctor from the IAEA's Division of Nuclear Safety investigated the medical consequences of the accident and the author investigated the radiological protection aspects. In April, the patient was transferred to a hospital in Paris which has experience of treating radiation overexposures. In July 1993 the physicist was suffering an increasing level of pain and the doctors decided to amputate his right hand at the wrist.

5. Accident investigation

After interviewing the physicist and all relevant staff at the Institute, and inspecting the accelerator facilities the author concluded that the accident occurred due to a complete lack of safety systems, a lack of training in radiation safety and a break down in communications. To attempt to assess the radiation dose to the physicist's hands and body, measurements were made in the main radiation beam and at the position where he had been leaning over the x-ray target. It was established that immediately above the sample chamber the radiation levels changed rapidly with distance, and where the physicist had been standing they varied from 10 mGy min^{-1} up to 1.4 Gy min^{-1}. Dose rates in the main beam were estimated as being as high as 1000 Gy min^{-1} at a distance of 5 cm from the target. Neutron radiation levels were not measured owing to the unavailability of suitable monitoring equipment.

Where such high dose rates and steep dose gradients are concerned exact details of the accident are crucial if the measurements are to be used to accurately assess doses. The physicist was unable to provide these and the stage at which the accelerator was switched on is not known. It was therefore concluded that the dose to the physicist could not be estimated from the measurements, and other forms of dose assessment had to be considered. It was established that the physicist was wearing a long sleeved cotton shirt at the time of the accident. This shirt along with part of a finger bone that had been amputated were sent to the Institute of Biophysics, Moscow for analysis by electron spin resonance (ESR). The French authorities were also able to carry out an assessment of whole body exposure by chromosome aberration analysis.

ESR dosimetry on the bone samples gave an estimated average dose of 45 ± 11 Gy to the 3rd right finger. Similar analysis of the physicists shirt gave doses of 30 ± 10 Gy and 20 ± 6 Gy respectively to the front and back of the right cuff, and 8 ± 3 Gy to the left cuff of his shirt. The results of the chromosome aberration analysis indicated a dose of 1.5 Gy to the upper body.

During the investigation it was also possible to estimate general occupational doses by carrying out a radiation survey outside the accelerator room. With the machine operating at 15 MeV, 3 μA, dose rates of up to 200 μSv h^{-1} were measured outside the accelerator room door, and 25 μSv h^{-1} in the control room. Although these levels were unacceptably high, and would have been proportionally higher at higher beam currents, it was considered unlikely that occupational dose limits had been exceeded when occupancy factors and equipment usage were taken into consideration.

A full report[1] of the accident has been published by IAEA.

6. Remedial action

Soon after the accident the Institute fitted a magnetic interlock to the accelerator room door and reinstated a manually operated pre-warning system. The Institute has also implemented the following additional actions subsequent to the accident investigation:-

a) A radiation detector has been installed to sound an alarm and illuminate a flashing light if radiation is present above ambient background levels.

b) A video camera with TV monitor system has been installed. The camera is inside the accelerator room and the TV monitor is next to the control console.

c) Additional local shielding has been provided around the tungsten and uranium targets.

d) Lead shielding has been attached to the corridor walls between the accelerator room and the control room.

e) Warning notices are displayed outside the accelerator room.

f) Two portable dose rate monitors are available.

g) Procedures for radiation safety have been issued.

h) Radiation protection officers have been appointed.
It is understood that training in radiation safety has not yet been provided.

7. Conclusion

Accident investigation reports such as that undertaken by IAEA provide valuable feedback that can be used in training both for new staff, and for updating and reminding existing staff of the safety measures needed to prevent accidents and how to deal with those that do occur. This accident investigation revealed little that is new, but underlined the need for a systematic approach to protection that considers engineering controls, operating rules and training.

8. Acknowledgements

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IAEA-CN-70/26

THE LESSONS FROM THE RADIATION ACCIDENTS IN CHINA OVER THE PAST 40 YEARS

XA9848203

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Abstract

A brief introduction and analysis of the radiological accidents in China during the past 40 years have been made in this paper. Statistical data provided by the competent authority show that a number of cases of radiological accidents and events happened in China from 1954 to 1994. Quite a few persons received abnormal exposure. Some serious accidents resulted in death of 8 victims. The reasons of these accidents are analyzed and some recommendations for reduction of potential exposure and accidents involving radiation sources and equipment generating ionization radiation have been given, such as perfecting and improving radiation safety infrastructure and system for the control of radiation sources. It is suggested that safety culture shall be fostered, each individual must be suitably trained and qualified and the management of spent sources should be strenthened.

1. Introduction

With the development of nuclear technology, the application of radiation sources in industry, agriculture, medicine, research and teaching is wide-spread, and increasing in China. The use of radiation brings huge benefits to the Human, and meanwhile it produces some radiation risks. The radiological accidents occurred sometimes during the past 40 yeas in China. According to radiological accidents management regulations[1] issued jointly by the Ministry of Public Health and the Ministry of Public Security, radiological accident defined as the abnormal events dealing with lost control of radioisotopes or apparatus that generates ionization radiation, resulting in over exposure to people or radioactive contamination. Investigation carried out by relevant competent authority shows that a number cases of radiological events and accidents happened in whole country from 1954 to 1994, resulting in over exposure to qutie a few persons. Among them 90% cases were first and second level accidents or events. Third level accidents were about 10%[2]. Very serious accidents causing death are shown in Table 1.

In addition, because of the failure of ¦Ã therapeutic equipment and a medical accelerator, two accidents had happened which resulted in indirect death of 2 and 13 patients respectively. The radiological accidents mentioned above not only made many persons received abnormal exposure, but also resulted in huge economic losses. Obviously it is necessary to analyze the reasons of the accidents and learn from the lessons to prevent similar accidents.

Table 1 Causing death radiological accidents

NO	Years	Place	Reason	Number of death
1	1963	Anhui	Source lost	2
2	1985	Heilongjiang	Source lost	1
3	1990	Shanghai	Safety interlock failure	2
4	1992.11	Shanxi	Source lost	3

2. Analysis of the accidents

1) About 80% of the accidents happened during the past 40 years were liability accidents related to human factors. About 20% cases were caused by the failure of equipment.
2) More than 50% of the radiological accidents belong to events or accidents due to theft and loss of small sources with low activity. From 1981 to 1992, several hundard of radioactive sources were lost owing to the poor management. To enforce radiological protection management and to avoid radiological accidents, "Regulations on the protection of radioisotopes and radiological equipment" was issued by the State Council[3]. However, the regulations were not be observed strictly. Notification, registration, and licensing were not carried out strictly according to the regulation. Operational guides and health physics programs were not established too. For instance, in the radiation facility in Xinzhou where a major radiation accident took place, the facility was operated for many years without license, the sources were not registered and filing correctly. This situation led to a major accident when the facility was decommissioned, the number of sources transferred only based on the memory of people in the facility, as a result, one source was left in the well for source storage and out of control, a major accident happened [4][5].
3) Regulation authorities were short of powerful supervision and monitoring. There was no effective monitoring measures to discover and treat the accident instantly in the institutions where accident had happened.
4) About 20 accidents happened for irradiation equipment from 1985 to 1994, 5 people died in these accidents (including the accident in Xinzhou). The main causes of the accidents in the facilities are the poor management system and the low technical level of individuals. Moreover, it is also an important cause that the workers entered accidentally into irradiation rooms due to lacking defense-in-depth measures in design and no safety interlock system or failure of the system in some facilities[6]. In some radiation facilities, the interlock system was dismantled and not recovered when the facilities were put into operation again. This kind of mistakes caused some accidents, "6.25" accident belongs to this kind, in this case, 7 people were exposed (2-12 Gy) and 2 of them died[7].
5) Radiation workers had not got enough knowledge on radiation safety and protection. Without accepting proper training previously, they were not familiar with the regulations and procedures on radiation protection. The operational guides were even violated sometimes. These cases existed in almost all the accidents mentioned above.

3. Suggestions

1) It is necessary to establish and improve national radiation safety infrastructure, perfect the system for the control of radiation sources. Standards and regulations relating to radiation sources safety should be reviewed and improved. The detail guidance of radiation sources safety should be worked out also.
2) Radiation protection standards and procedures, especially the system of notification, registration and licensing etc., should be carried out completely.
3) Sources shall be kept secure so as to prevent theft or damage. Registration and licensing should have an accountability system, including records of the location and description of each source, to ensure that all of the sources are under control all the time.
4) Safety culture shall be fostered to ensure that the protection and safety responsibilities of each individual, including those at management level, be clearly identified and each individual be suitably trained and qualified.

7) At present, there are large amount of spent sources in China and most of them are out of use. To prevent the sources from loosing and resulting in radiation accidents and events, the spent sources management (such as registration, storage and filing) must be strengthened. It is necessary to research on the conditioning, management and disposal of spent sources. It is suggested to centralize the storage and management of spent sources.

4. Conclusion

Extensive experience have been learnt from the radiation accidents occurred over the past 40 years. At present, referring to IAEA Safety Series NO 115 (BSS), basic safety standard of radiation and standards related to radiation application are being revised and drafted in China. The lessons from the accidents will be considered and fed back in the new standards.

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IAEA-CN-70/37

SOME SAFETY ASPECTS DURING THE REPLACEMENT OF COBALT-60 SOURCES IN TELETHERAPY

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Abstract

Some recent radiation protection problems arised during the replacement of the old Cobalt-60 sources in teletherapy in Romania. There are pointed out the potential radiation risks for the population and the lack of appropriate regulation for the field.

1. Introduction

According to 1993 United Nations Scientific Committee Report on the Effects of Atomic Radiation, in Romania since 1972 there are in operation 20 Cobalt-60 units for teletherapy, most of them of ROKUS-M type (from former USSR). Due to radioactive decay, during the last years was necessary to replace the old Cobalt-60 sources with the new ones.

At the beginning the problems were determined by the impossibility to get sources of original type (ROKUS). They were not any more available in the market.

This situation obliged the potential users to look for similar radioactive sources in the international trade, but two difficulties were noticed at this moment:

- the holder of the Cobalt-60 source in the ROKUS unit has a special design, which do not allow an ease replacement of the source with any new source;
- the expensiveness of a new Cobalt-60 source.

In this situation, they were imposed to order from intermediate suppliers old Cobalt-60 sources (taken from old units) of similar (but not exactly) design and size with ROKUS sources.

2. Results

The radiation protection problems arised during and after placement of the new (from the point of view of the new user) Cobalt-60 source.

In order to be placed in the holder , within the ROKUS head of the unit, due to a different design and size, some mechanical adjustments of the new source were necessary.

During a control performed by the radiation protection expert from the local radiation hygiene laboratory, a **surface contamination with Cobalt-60 of the therapy table was found.** Up to now, it is not very clear if this radioactive contamination was determined by the adjustment operation of the new source, by a previous external contamination of the source, during its consecutive transfer through several places (from " original " Cobalt-60 teletherapy unit to the present user) or by an external contamination of the transport container.

Were measured also ^{238}U (about 885 Bq per 100 cm^2) and ^{235}U (about 20 Bq per 100 cm^2), which were clear from the head of the Cobalt unit.

An additional surprise was the value of output of the teletherapy installation, measured using the dosimetric facilities of the Secondary Standard Dosimetry Laboratory - Bucharest (in the Institute of Public Health). The real absorbed dose rate in water, for the standard field (10 x

10 cm x cm) was 30 % less the expected value from the certificate provided by the intermediate supplier of the source.

As the source was not accompanied by its original calibration certificate, the supplier's certificate included only a " calculated " value of activity from a (supposed) " original " certificate, the only explanation of this big discrepancy could be (intentionally or not) error in this calculation of the activity of the source. The "intentional" error could be given by the fact that the cost of the source is direct proportional to the stated activity.

A final radiation protection problem of this real story was to find an appropriate storage place for the own old Cobalt-60 source, having enough activity to represent a health risk for the population.

3. Conclusions

The practical consequences of the presented case situation are:

- the need of an international co-operation for establishing an appropriate database and a reporting system for all old used Cobalt-60 sources from teletherapy;
- the need of an agreed methodology for verification, including safety assessment, of the replacement procedure of Cobalt-60 sources in teletherapy.

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XA9848205

RADIATION INCIDENT IN OIL WELL LOGGING

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1. Abstract

On June 4th 1997 equipment failure and violation of approved procedures by a crew of workers initiated a series of events that resulted in the unnecessary exposure to neutron and gamma radiation, from a 666 GBq Am241Be source, of forty two workers from a well logging company in Venezuela. Due to the presence of dry mud or drilling fluids inside the logging tool, the nosepiece was screwed off the rest of the source holder; this piece was mistaken for the entire source holder thus leaving the source inside the tool. The tool was labelled for maintenance and electronic laboratory personal worked near the source for seven hours before they identify its presence. As soon as the incident was detected a contingency plan was implemented and the source could be retrieved from the tool and placed in its shipping container. The TLD badges indicate doses well below the annual limit of 20 mSv, and none of the workers involved in the incident seem to show serious health consequences from it. After the incident, in order to avoid the occurrence of similar situations, a better source and tool maintenance program was implemented, all the workers were re-trained, and area monitors were installed in all operations bases.

1. Introduction

In Venezuela the first oil well was logged in 1933 using conventional techniques, in the 1950's radioactive well logging was introduced in the country. At present seven companies carry out this type of work at the national level and several radiological incidents have occurred. The main causes of these incidents have been equipment failures, carelessness and violation of approved procedures.

One of the radiation incidents, which have occurred, will be described with its causes and consequences.

2. The incident

After running log of well "GUN-1X", located in north-western Venezuela, near the Colombian border, the neutron-logging tool was retrieved from the well. According to company procedures, approved by the Competent Authority, only Field Engineers can manipulate radioactive source. Since he was busty, a member of the crew proceeded to extract the source holder from the logging tool's pocket, using a half a meter long handling tool specially designed to manipulate Am241Be sources.

The source involved in the incident was a 666 GBq Am241Be source, which according to the manufacturer produces a neutron dose rate of 0,396 mSv/hr and a gamma dose rate of 0,45 mSv/hr at one meter [1]. The source is double encapsulated and placed in a source holder coded S17S20 P/N 089599 by the well logging company [2].

A member of the working crew member tried to screw off the source holder from the logging tool but due to the presence of dry mud or drilling fluids inside the tool, he screwed off the nose piece from the rest of the source holder. Since he did not know how the source holder looked like he mistook the nose piece for the entire source holder, and placed this piece inside the shipping container, leaving the rest of the source holder which contained the source inside the logging tool.

There was an available survey meter, in working condition, in the logging truck but nobody made a radiation survey, even-though a member of the crew reported to the field engineer that he had had trouble extracting the source holder from the logging tool.

The logging tool, containing the unshielded source, was labelled with a red sticker by the Field Engineer, a standard procedure to indicate the need for maintenance, and placed in a basket located 12 meters from the working area. The tool remained in that place for eighteen hours before it was placed in a truck and transported to the operations base, the trip took about three and half-hours.

Upon arrival to the base, on June 5^{th}, the logging tool was placed in the cleaning area, where it remained for ten hours before being washed and sent to the electronics laboratory, due to the presence of the red sticker. It was in the lab that the highest exposure to radiation took place due to the short distances to the source and long time it took to discover the presence of the source.

In the laboratory, the Engineers and Technicians noticed a high electronic reading but could not find out what was wrong with the tool, since they all assumed that the radioactive source was not inside. They worked on the tool for five straight hours, from 4:30 to 9:30 p.m., at a distance of about a meter. At 9:30 p.m. they decided to stop working and to continue the next day.

In the morning of June 6^{th}, they continued their work on the tool, for two more hours, at 9:30 a.m. the Engineer in charge of the Lab reached the conclusion that the only reason why the tool could give such electronic response was if a source was still inside. He went to get a survey meter and detected the presence of the source [3].

3. Contingency plan

As soon as the incident was identified the Radiation Safety Officer executed the contingency plan, which consisted of the following actions [4]:

- The source holding pocket was removed from the logging tool and placed in a security area properly identified as a radiation zone.
- In the storage bunker the shipping container is located and the source's nosepiece is retrieved.
- The nosepiece was grinned to facilitate its entry in the source holding pocked, and it was screwed on the bottom piece, which contained the source.
- The entire source holder, now as one piece, was removed from the source holding pocket and a sample was taken for a removable contamination test, which later proved negative.
- The source holder was placed in the shipping container, which was labelled because the source housing could not be used with logging tools due to the damage of the nosepiece by the grinding.
- All the people involved in the incident were identified and sent to a clinic for full blood and eye examinations, follow up blood exams were done five and fifteen days later.
- The TLD dosimeters were collected and shipped for urgent processing.
- All the personal involved in the incident were temporarily removed from work with radioactive material.
- A radiation safety meeting was held with the entire base personal to explain the situation.
- The competent authority was informed of the incident on June 6^{th} by fax.

4. Health consequences to workers

The doses received by the workers with the higher exposure [5] and the results of the clinical examination [6] [7], of all the workers that showed any deviation from normal health conditions are shown in Table I.

All the remaining workers involved in the incident didn't show any health problems and their dosimetry does not indicate any dose above the system's minimum detection level.

Several workers involved in the incident were not classified as Occupationally Exposed Personal, due to their functions within the company, but none of the cases studied seem to show serious health consequences from the incident.

TABLE I. DOSES AND RESULTS OF CLINICAL EXAMINACIONS

Case	Neutron Dose mSv	Gamma Dose mSv	Result of Clinical Examination
GM	0,352	0,4	Normal
JA	0,176	0,2	Normal
NM	0,176	0,2	Normal
NA	0,352	0,4	Normal
RE	0,264	0,3	Normal
JC (*)	N/A	N/A	Slight Anaemia
LA (*)	N/A	N/A	Slight Anaemia
AL (*)	N/A	N/A	Low White Cell Count /Common Cold
RS (*)	N/A	N/A	Slight Anaemia
AC (**)	N/A	N/A	Low White Cell Count /Common Cold
NR (*)	N/A	N/A	Slight Anaemia
JCS (**)	N/A	N/A	Low White Cell Count

(*) The second blood test showed normal results.

(**) Workers under haematological control.

5. Corrective actions taken

After the analysis of the incident's causes the following actions were taken:

- A better maintenance program was started in order to assure the working conditions of all logging tools, sources, source holders and housings before field work.
- All the workers were re-trained on radiation safety and operational procedures.
- A safety procedures campaign was carried out to increase the awareness of its importance, in the operations base and the fields, among all the Field Engineers and crewmembers.
- The Field Engineer that violated the procedure was suspended from fieldwork for two months and assigned to the Industrial Safety Department of the company.
- Internal and external audits were carried out in all the operations bases and field locations.
- Installation of area monitors in the tool washing section and calibration laboratories of all the bases that the company has in Venezuela.

6. Conclusions

The causes of the incident were equipment failure and mainly violation of approved procedures, which if used could have detected the abnormal situation at the same moment it occurred.

None of the workers involved in the incident seem to show serious health consequences from its occurrence.

After the incident a better source and tool maintenance program was implemented, all the workers were re-trained, and area monitors were installed in all operations bases. The effectiveness of these actions is now under evaluation.

It should be emphasised that this kind of incident can repeat itself in other countries if approved procedures are violated.

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LA REPONSE POUR LES CAS DE DETECTION ET DE SAISIES DE MATIERES RADIOACTIVES

M.H. PERON

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THE RADIOLOGICAL ACCIDENT IN TBILISI

XA9848206

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Abstract

On 9 October 1997 a facsimile message was received by the IAEA from the Minister of Health of Georgia stating that servicemen of the Lilo Training Detachment of Frontier Troops had developed local radiation induced skin diseases on various parts of their bodies. Details were sent of the medical diagnoses of the nine victims together with information on the radiation sources and dose rates that had caused the exposures. The Georgian Minister of Health requested the IAEA to assist in the examination and treatment of the patients. An investigation had revealed that several Cs-137, Co-60 radiation sources and some beta emitters had been found and that in some places high dose rates had been detected. The Government of Georgia requested the IAEA to send an emergency team to evaluate the radiological situation at the Lilo Training Center. The present paper is a summary of the finding and lessons to be learned from this situation.

1. The accident

The Lilo Training Detachment of Frontier Troops is located in a remote site about 25 km east of Tbilisi. The Center covers approximately 150,000 square meters. There are three 3 main areas: the living and management area which cover several buildings for soldiers and officers; the living quarters, where some of the officers lived with their families and the empty buildings used for training .

In the past the center was used by Soviet troops for Civil Defense Training. The sources may had been used for calibration of survey equipment and radiological monitoring training in the case of a nuclear accident or nuclear war. The site was transferred to the Georgian Army in 1992. The chronology of the accident is as follow:

April–August 1997: Soldiers from the Lilo Center developed skin burns on several parts of their bodies. From the clinical situation the exposure was fractional and occurred over the course of several months. There is no information on the time and circumstances of when the exposure began.

26 August 1997: A radiation hot spot was discovered at the Lilo Center near the underground shelter. The dose rate was about 45 mGy/h. The measurement was carried out by officers from the Chemical, Radiological and Biological Protection Division of the Georgian Army.

5 September 1997: Second measurement carried out by the same personnel and the representative of the State Sanitary Supervision and Hygiene Standardization to confirm the high radiation levels.

10 September 1997 : The Georgian authorities contacted the Center of Applied Research of the Institute of Physics and its Safety and Radiation Protection Department. A Working Group (WG) was established to assess the radiological situation at the site.

2. RADIOLOGICAL ASSESSMENT

The WG started monitoring the area on 11 September 1997. The complete lack of information about the sources made their task more difficult. No information was available on the type of radionuclide, chemical and physical form, activity, etc. The survey began close to the underground shelter. On September 12 the exact location of one source was determined but owing to the high dose rate at the location and the lack of a lead container to store the source, no action was taken. On 13 September a source was removed from the pocket of a soldier's winter jacket. and later placed inside lead shielding. The source was a metal cylinder with a diameter of about 6 mm and a height of about 12 mm. Additional measurements showed that there was no radioactive contamination at the location .

Slight increase to the background level was determined near to that site. Another source was found at the soccer field located 130 m from the underground shelter and few meters from the official building. In this case the source was approximately 30 cm below the surface. On the same day elevated dose rates were discovered just a few meters from the smoking area. The third source was found 10 cm below the surface. At that stage the WG decide to survey the whole facility and its environs. Detailed measurements were carried out continuously during the following days. A total of 250,000 m^2 were monitored. Results are as detailed in Table I.

TABLE I. SUMMARY OF THE SOURCES FOUND AT THE LILO TRAINING CENTRE. INFORMATION PROVIDED BY THE GEORGIAN AUTHORITIES
(Γ= 79 μGy/h m^2 GBq for Cs-137)

Location and source number	Date	Radionuclide	Dose rate at the ground surface (mGy/h)	Dose rate at 1 m distance (mGy/h)	Estimated activity (GBq)	Place where the sources had been found
1	13.9. 97	Cs-137	-	13000	164	Coat pocket
2	13.9.97	Cs-137	2	9954	126	Soccer field
3	13.9.97	Cs-137	0.15	30	0.37	Smoking area
5	14.9.97	Cs-137	35	70	0.88	Outside area
6 and 7	19.9.97	Cs-137	20	2	0.02	Outside area
8	19.9.97	Cs-137	10	50	0.63	Outside area
9	19.9.97	Cs-137	8	1.5	0.01	Outside area
10	20.9.97	Cs-137	-	2	0.02	Scrapyard

Dose rate at the distance of 1 m after removing the source from the ground. The value is the result of several measurements at different distances. Two other Cs-137 sources were found, but because they were inside of their lead containers, the dose rate at the surface of the container was very low. A group of about 200 units of night shooting guides containing Ra-226 were also found at different places at the facilities. A Co-60 source at a location 4 was found with very low dose rate.

3. Source recovery and temporary storage

The sources are temporarily stored at the Lilo site next to the scrapyard. The first six sources are inside the lead shielding provided by the Institute of Physics. The rest of the sources are inside their lead containers found at the site. The physical protection of the source is assured by the Detachment of Frontier Troops. The storage room is locked, clearly identified and security surveillance is maintained during the whole day.

4. THE IAEA MISSION

The IAEA team made a radiological monitoring survey in the internal and external areas of the Lilo Center. All the green areas and various buildings were surveyed. The values correspond to the background levels. The surface contamination measurements show no contamination at all at the site. Additional tasks to collect and process the information on the sources provided by the Georgian WG and to assess the adequacy of the storage of the sources, were accomplished.

The temporary storage room was very carefully monitored. The dose rate values at the outside surface of the walls of the room are similar to levels due to natural background level of radiation. All containers were measured at the surface. At 3.5 m from the group of sources the dose rate is at the level of background radiation.

5. INDIVIDUAL DOSE ASSESSMENT

Estimates of internal doses for the patients has not proved necessary in this accident since all the radiological surveys made at the sites show that none of the sources were damaged or leaking radioactive material and the environment was also free of radioactive contamination.

Following many radiological accidents dose estimates based upon radiological information on the sources involved, ambient dose rates and a reconstruction of the sequence of events can provide valuable information for the initial screening of the irradiated persons as well as estimation of the doses they may have received. For the Georgian accident this has not proved possible since there is insufficient information available on the relevant parameters contributing to the irradiation of the persons involved. The dates and times of irradiation are not known, neither are the specific sources producing the irradiations or the exposures geometries. The patients have also not been willing to discuss the circumstances surrounding their exposure. Because of these problems in reconstructing the many scenarios assessment of the external doses received have not been made. Inspite of this, theoretical calculations have been made based upon doses calculated from the largest sources activity and assuming simplified irradiation geometry. For a limited number of irradiation geometries exposure time have been estimated to produce the observed clinical injuries.

6. Lessons to be learned

The review of radiological accident is a mechanism for feeding back experiences into the relevant system of control, in order to help lessen the likelihood of accidents in the future and to be better prepared for those that do occur. Such reviews add to the fund of knowledge, and also illustrate and emphasize principles and criteria, which, however, are usually already well known. This is reflected in the observations and recommendations that follow, which derive from the review of the radiological accident in Tbilisi , Georgia but not necessarily from the specific circumstances of the accident.

Lack of documentation relating to the plant suggested that there had been only limited contact between the former sources owner and the current operating institutions; this was possibly due to changes in organizations and their responsibilities in the former USSR republics. The absence of official data on the presence of radioactive sources at the territory of Lilo training center caused partly the delay of identification of the radiological accident. Also the lack of routine environmental monitoring at a national level made impossible the early detection of the emergency.

Although after the identification of radioactive emergency the necessary actions were taken promptly, the absence of appropriate emergency response plan created additional difficulties. The lack of up-to-date equipment, adequate training of the staff and financial resources made the situation very difficult. The necessity of multilevel system of emergency response and preparedness is evident. The national emergency plan would consist of clear distribution of responsibilities, particularly naming the unit dealing with in-field actions. Such unit, as well as the source of emergency funding, must be designated by law or special regulation at a national level.

The lack of appropriate medical experience regarding the radioactivity-originated diseases caused the long period between the hospitalization of victims and verification of final diagnosis. The country-level measures for the wide dissemination of information for physicians aiming to deliver them at least a minimum knowledge in symptoms of radioactive-caused diseases are needed. At least one well-equipped medical team with trained staff should be designated by the national emergency plan for the prompt reaction in case of identification of radiological emergency.

International cooperation has facilitated significantly both of the treatment of persons injured and the initiation of the actions necessary for the avoidance of such accidents in future. A permanent contact with international organizations, particularly IAEA and WHO, and the clear understanding of possible ways, mechanisms and schemes of international cooperation by relevant national authorities would be a significant factor of decrease the risk and scale of possible accidents.

Appropriate international organizations should consider having ready for use radiological equipment available. Should also consider having a set of radiological equipment at hand ready to be shipped and an emergency preparedness group formed by in-house staff . Personnel using instruments should be trained to be able to obtain a clear indication of dose rate response, for a wide range of doses; and to know the most suitable equipment in different conditions and its calibration factors. Instrumentation should be capable of being adjusted to withstand field conditions, so that it can be used in high humidity, high temperatures and unstable environmental conditions and altitude variations.

ACCIDENTS IN INDUSTRIAL RADIOGRAPHY AND LESSONS TO BE LEARNED - A REVIEW OF IAEA SAFETY REPORT.

XA9848207

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Abstract

This IAEA Safety Report Series publication is the result of a review of a large selection of accidents in industrial radiography which Regulatory Authorities, professional associations and scientific journals have reported. The review's objective was to draw lessons from the initiating events of the accidents, contributing factors and the consequences. A small, representative selection of accident descriptions is used to illustrate the primary causes of radiography accidents and a set of recommendations to prevent recurrence of such accidents or to mitigate the consequences of those that do occur is provided. By far the most common primary cause of over-exposure was "Failure to follow operational procedures" and specifically failure to perform radiation monitoring to locate the position of the source. The information in the Safety Report is intended for use by Regulatory Authorities, operating organizations, workers, manufacturers and client organizations having responsibilities for radiation protection and safety in industrial radiography.

1. Introduction

The application of industrial radiography grew rapidly after the 1940s. Safety Standards vary and even though there has been significant improvement in the Regulatory Authority's radiation protection infrastructure in some IAEA Member States, overexposures and fatalities still occur. The dose rates that prevail close to a source or a device may be high enough to cause overexposure of extremities in a matter of seconds which may result in the loss of a limb. Whole body exposures resulting in a fatality are rare, but they have occurred when sources have been mishandled or have been in the possession of members of the public.

Industrial radiography accounts for approximately half of all reported accidents for the nuclear related industry, in both developed and developing countries. These accidents are primarily known to the small number of countries that have the regulatory infrastructure necessary to collect information and draw the benefits from the lessons learned. By studying the circumstances of each accident and the apparent deficiencies in safety, the regulatory system, the design and personnel performance, several measures can be identified which, if implemented, would improve safety performance in industrial radiography. There is a need to disseminate such knowledge gained and the lessons learned from these accidents, especially to those countries where the radiation safety infrastructure is weak or non-existent, so that others may benefit from the experience and implement the necessary changes in their regulatory, (licensing, inspection and enforcement) procedures and operational radiation protection.

The International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (the BSS) establish basic requirements for protection against the risks associated with exposure to ionizing radiation and for the safety of radiation sources that may deliver such exposure [1]. The BSS [Appendix IV.21], requires that, registrants and licensees shall be prepared to take any necessary action for responding to and correcting any reasonably foreseeable operating mishap or accident that could involve a source. On radiation emergency preparedness planning and response, the IAEA has issued several documents giving detailed guidance for responding to accidents with radiation sources [2-3] documents .

In order that all those involved in the manufacture, supply, use and regulatory control of radiation sources may learn lessons from accidents with an objective to reduce as far as possible the magnitude and likelihood of accidents, the BSS [IV.18-20] includes the following requirements;

"Registrants and licensees shall conduct formal investigations as specified by the Regulatory Authority if:

a) a quantity or operating parameter related to protection or safety exceeds an investigation level or is outside the stipulated range of operating conditions; or
b) any equipment failure, accident, error, mishap or other unusual event or circumstance occurs which has the potential for causing a quantity to exceed any relevant limit or operating restriction.

The investigation shall be conducted as soon as possible after the event and a written report produced on its cause, with a verification or determination of any doses received or committed and recommendations for preventing the recurrence of similar events.

A summary report of any formal investigation relating to events prescribed by the Regulatory Authority, including exposures greater than a dose limit, shall be communicated to the Regulatory Authority as soon as possible and to other parties as appropriate."

The IAEA has investigated and published reports including lessons learned , of some accidents with radiation sources [4-8]. Guidance for the safe design, procedural control and operation of industrial radiography equipment is contained in the IAEA Safety Report Series on practical radiation safety [9-11].

2. Scope and structure of the safety report

The Safety Report is the result of a review of a large selection of accidents in industrial radiography. The review's objective was to draw lessons from the initiating events of the accidents, contributing factors, the consequences and remedial actions taken. Section 2 contains an overview of scenarios of forty-three selected accidents, categorized by causes and analyzed for initiating and contributing causes. Lessons to be learned are discussed in Section 3. Section 4 gives a list of suggested preventive and remedial actions which if applied may prevent the recurrence of such accidents or mitigate the consequences of those that do occur. In the annexes, additional practical information is provided, i.e. such as details of basic training programme, and a glossary of terms.

2.1. Primary causes of reported accidents

Despite advances in equipment design and improved safety systems, accidents continue to occur owing to many factors: primarily failures to adhere to procedures and occasionally inadequate regulatory control. Several of the more severe accidents illustrate the consequences of failure to establish adequate human, procedural and equipment controls. One or more factors may combine to cause an accident. These may include an initiating event and many contributory factors. Attempts have been made to categorize the accidents by the primary causes. These are:

- failure to follow operational procedures;
- inadequate training;
- inadequate regulatory control;
- inadequate maintenance;
- human error;
- equipment malfunction and defect;
- design flaw;
- wilful violation.

An accident description and measures to prevent or mitigate the consequences of similar accidents are given under each of the above categories for illustration.

2.2 Failure to follow operational procedures

Failure to follow operational procedures, including the requirements of a Regulatory Authority, is a primary or contributory cause in the majority of accidents. This problem is seen across the entire cross-section of workers, from the most senior and well trained, who may become complacent, to the less experienced and untrained.

2.3 Inadequate training

The second most common cause of reported accidents is inadequacy of training, which includes ineffective initial and refresher training programme. This also includes unqualified personnel such as radiographer assistants working without supervision.

2.4 Inadequate regulatory control

A primary cause of accidents is inadequate regulatory control. This may be due to an ineffective Regulatory Authority or it may be that no radiation protection infrastructure has been established. Effective regulatory control by a system of authorizations is essential to establish standards for the possession, use and disposal of radioactive materials and the possession and use of X ray generating machines. These authorizations are intended to ensure that personnel are trained, that proper equipment in good working condition is used and that written procedures incorporating radiation protection and safety considerations are in place.

Where there is inadequate regulatory control, reporting procedures and data collection are commonly inadequate.

2.5 Inadequate maintenance

Numerous events are caused by inadequate inspection and maintenance of radiographic, ancillary and safety equipment. Failure to meet the manufacturer's recommended level of maintenance may result in wear, damage and breakdown of essential components. An inspection of equipment prior to its use will detect unsafe conditions such as loose fittings and crushed guide tubes. These should be corrected prior to performing radiography.

2.6 Human error

Even if equipment is operating properly and effective operating procedures are established, the safe operation of radiographic equipment relies heavily on the radiographers' judgement and response. The probability of human error increases during work under adverse and stressful conditions, such as of fatigue caused by night work, low light and high noise environments, production pressures and physical exertion. The probability of human error may also increase with substance use, misuse or abuse.

2.7 Equipment malfunction/defect

Although manufacturing defects are not common, they do occasionally occur. In addition malfunctions can occur as a result of the conditions of use.

2.8. Design flaw

Although design flaws are not common, they do occasionally occur. Design changes result from field experience and from ongoing development by the manufacturers, users and Regulatory Authorities.

2.9. Wilful violation

Training, equipment design and implementation of effective operating procedures cannot stop an individual from deliberately violating safety procedures. The probability of these deliberate acts increases when working, under stressful conditions due to substance abuse, fatigue, economic factors, production pressures or physical exertion. Wilful violations are more likely to occur in operating organizations where there is no strong safety culture.

3. Conclusion

A very important way of reducing potential exposures in the use of ionizing radiation is the prevention of accidents and mitigation of the consequences . To do this, it is necessary to feed back operating experience in both normal and abnormal situations. Accidents and incidents in the workplace must be formally investigated and documented. Others can then benefit from the lessons learned. The intended readership for this IAEA Safety Report include operators of industrial radiography equipment, management of operating organization, regulatory authority personnel, manufacturers of radiography equipment and clients of industrial radiography.

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LESSONS LEARNED FROM ACCIDENTS IN RADIOTHERAPY-AN IAEA SAFETY REPORT

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Abstract

Radiotherapy is a very special application from the view point of protection because humans are deliberately exposed to high doses of radiation, and no physical barrier can be placed between the source and the patient. It deserves, therefore, special considerations from the point of view of potential exposure. An IAEA's Safety Report (in preparation) reviews a large collection of accident information, their initiating events and contributing factors, followed by a set of lessons learned and measures for prevention. The most important causes were: deficiencies in education and training, lack of procedures and protocols for essential tasks (such as commissioning, calibration, commissioning and treatment delivery), deficient communication and information transfer, absence of defence in depth and deficiencies in design, manufacture, testing and maintenance of equipment. Often a combination of more than one of these causes was present in an accident, thus pointing to a problem of management. Arrangements for a comprehensive quality assurance and accident prevention should be required by regulations and compliance be monitored by a Regulatory Authority.

1. Introduction

Modern radiotherapy has three major concerns: efficacy, quality of life, and safety [1]. From the point of view of safety, radiotherapy is a very special application of radiation because: humans are directly placed in a very intense radiation beam (external beam), or sources are placed in direct contact with tissue (brachytherapy); very high doses are intentionally delivered; no physical barriers can be placed between the radiation source and the patient. Moreover, a radiotherapy treatment involves many professionals participating in a large number of steps between treatment prescription and treatment delivery, and a large number (25 or 30) of treatment sessions, in which many parameters have to be adjusted. Not only overdosage but also underdosage may have severe consequences in radiotherapy, and constitutes an accidental exposure. The potential for an accident in radiotherapy is therefore very significant and deserves special measures for prevention.

2. Scope and structure of the report

The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources [2], place general requirements as well as detailed requirements specific to medical exposure, including exposure of patients. The specific requirements include the investigation of accidental medical exposure, and to draw corrective measures to prevent reoccurrence. A number of IAEA's reports on individual accidents involving staff and public have been issued [3-8]. Recently, a report on an accidental overexposure of radiotherapy patients in San José, Costa Rica, has been published as well [9]. In addition, an IAEA's Safety Report in preparation [10] reviews 90 radiotherapy incidents and accidents in order to provide a comprehensive number of lessons that can be used as a check list to test vulnerability of a facility to potential accidents and a basis for improving safety.

3. Causes of accidents

For each event, a short case history is followed by an identification of the initiating event and other factors that contributed to the incident or accident. The causes can be summarized as follows.

Table 1. Overview of the most relevant accidents

Country	Year	No of patients affected	Causes and main contributing factors
USA	1974-76	426	Error in decay table for Co-60 No independent verification More than two years without beam verification
Germany	1986-87	86	Error in dose tables Co-60 (varying overdoses) No independent determination of the dose rate
UK	1988	207	Error in calibration Co-60 unit (25% overdose) No independent calibration of the beam
UK	1988-89	22	Error in identification of Cs-137 sources (-20 to +10% errors) No independent determination of source strengh
Spain	1990	26 (several deaths)	Error in maintenance of a linear accelerator Procedures, to inform the physicists, when transferring the machine from and to the maintenance technician, were not followed. Conflicting signals and displays ignored Daily beam verification (QA) not in place
UK	1982-91	1045	Inappropriate commissioning of a TPS (5-30% underdosage)
USA	1992	1 (death)	Brachytherapy source left inside the patient HDR source dislodged from equipment Conflicting monitor signals and displays ignored
Costa Rica	1996	115 (several deaths)	Error in calculation during calibration of Co-60 beam Lack of independent calibration and of QA Recommendation of previous external audit ignored

3.1 Deficiencies in education and training

Insufficient education and training in radiotherapy physics was a major contributor to accidents originated at the calibration of radiation beams and brachytherapy sources. As indicated in the table, this type of accidents involved a very large number of patients. Untrained physicians working without supervision was the cause of some confusion and wrong treatment delivery. Lack of training of brachytherapy nurses was the main cause of accidents with radiation sources in the brachytherapy ward. Insufficient understanding of the physical beam parameters by a maintenance technician led to a misadjustment of the energy of an accelerator which caused an accident with devastating consequences to many patients.

In general, the training for all professionals was only for normal situation but did not include identification of unusual events and situations. This fact contributed to make it possible for an initiating event to be undetected and become an accident.

3.2 Deficiencies in procedures and protocols

Severe accidents were due to inadequate commissioning of an equipment, i.e., without following accepted procedures and protocols. Not only machines and sources but also treatment planning computers and ancillary equipment and accessories were involved in accidents due to improper commissioning and use, i.e., without adequate procedures. Acceptance of brachytherapy sources without verification of activity, confusion of units of source strength were also causes of accidents.

Procedures for transferring equipment for a repair or a maintenance work were not followed and equipment was returned for treatment were. Deficiencies of procedures and documentation of treatment prescription and treatment planning, patient identification and patient set-up were present in some of the accidents as well.

3.3 Deficient communication and transfer of essential information

A frequent cause was misunderstanding of treatment prescription or of a treatment plan or data related to identification of a patient. Change of personnel without a formal transfer of information relevant to calibration and treatment planning. These cases can be considered due to ineffective procedures for communication and documentation as well, but mentioning separately.

3.4 Insufficient defence in depth

In many of the accidents, a single mistake progressed undiscovered to an accident; these accidents could have been prevented if defence in depth had been incorporated into the radiotherapy system. For example, mistakes in the calibration of the beams could have been discovered by and independent calibration made by a second person, for any new beam (for example, after a source change), and by as checking the calibration results for compatibility with the values given in the certificate of the source manufacturer. A systematic application of appropriate level of defence in depth to safety critical situations would drastically reduce the potential for accidents.

3.5 Deficiencies in design, manufacture, testing and maintenance of equipment

A few accidents involved deficiency in design and testing, but the consequences were fatal. In one fatal case, factory tests did not anticipate situations and operating conditions that may occur in practice and it took the manufacturer too long to identify the cause and to disseminate information to other users and to take corrective actions. In another case, unresolved equipment faults led to a decision to operate in a non clinical mode (interlocks defeated) which resulted in a fatal accident.

3.6 Inattention and unawareness

Treatment delivery involves a very large number of steps using a large amount of data, in almost repetitive way and yet different from one patient to the next one. For every session, data have to entered on the patients' charts, up to about hundred sessions every day. Examples of inattention were related to using the wrong prescription, the wrong patient chart or the wrong parameters. Treatment preparation and delivery needs permanent concentration which may be difficult to maintain all the time. Measures to increase attention and awareness, appropriate working environment, not prone to distractions and double checks are necessary (two persons in the set-up).

4. Summary and conclusions

In many of the accidents, there was a combination of causes: a deficient training in radiotherapy physics was combined with a lack of defence in depth, non existence of procedures and absence of overall supervision. A combination of causes often points to a management problem which allowed operation in the absence of essential institutional arrangements, such as a quality assurance programme. Institutional arrangements should be subject to appropriate requirements by means of regulations, complemented by verification of safety by monitoring of compliance with the regulatory requirements.

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THE IMPORTANCE OF GOVERNMENTAL CONTROL OF RADIOACTIVE SOURCES USED IN INDUSTRIAL APPLICATIONS

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Abstract

Industrial applications of radioactive sources require good management practices dealing with control and registration.
In the following case, a special event occurred between two routine inspections: trading. Then a new human factor came into scene: workers with no specific training and knowledge related to radioactive sources.
The upgoing situation triggered emergency procedures.
Finally, there were no negative consequences.

1. Introduction

It is a well-known fact that devices containing radioactive sources are used in various activities, including industrial applications.
The case we are taking into consideration here is that of a factory where nuclear techniques were utilised in order to control its industrial processes. From now on we name the owners of this factory as "Firm A".

Nine sources of ^{137}Cs (each of approximately 100 mCi) were used in routine procedures related to adequate filling control of beverage bottles.
Firm A asked the official authorities for periodical controls of all the equipment containing the sources mentioned above. The inspection of the sources and instrumental here involved included the inspection of the working area and storage conditions.
Firm A followed any suggestions made by the radiological protection officer in turn.
No irregularities were ever found.

In August 1996, Firm A asked the National Directorate of Nuclear Technology (DNTN) for implementation of measures tending upward the safe disposal of their radioactive sources. This because the equipment containing the sources would not be used in the future by Firm A.
On that occasion, and as DNTN had not yet an appropriate storage place for the sources implied, Firm A was told to keep the equipment containing the sources until DNTN could find an adequate and definite solution.

2. Situation generated after the sale of the factory

In December 1996 the factory of Firm A was sold to Firm B.
In April 1997, Firm B asked DNTN for an urgent action as a box containing radioactive material had appeared in its industrial installations.
Such material consisted of the nine sources of ^{137}Cs Firm B had no idea of its existence before buying the factory of Firm A.
Just in April 1997 Firm A communicated to Firm B the existence of such sources in the factory, letting them also know that DNTN was the governmental authority responsible for radiation protection and suggesting to ask for their advice related to the Caesium sources.

In May 1997, the sources were transported by authorised personnel of DNTN to the CIN (Nuclear Investigation Centre) of the University of Uruguay. In December 1996, an appropriate storage place for radioactive sources, had been built at the CIN's installations. *All* transport features and storage conditions implied in this case were made following the recommendations given by IAEA Ref. [1].

3. Conclusions

Fortunately this was only a case of potential danger of exposure to radioactive material by persons of the public or non-occupational exposed workers.
But a "black box" takes part of this event and several questions can be made related to this case. Those may imply not only the lack of adequate communication during trading, but also judgements of guiltiness or innocence and responsibilities derived.
Nowadays, radiological emergencies are attended by a group of technicians belonging to DNTN.

5. REFERENCE

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LEAKAGE OF CAESIUM BRAQUITHERAPY SOURCES

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Abstract

In several Venezuelan public hospitals where cervix uteri tumours are treated by intracavitary radiotherapy, that use manual after loading Fletcher method, with Caesium 137 sources, the use of improper source holders, locally manufactured from pieces of drainage plastic tubing, which deteriorated and created a corrosive environment all around the sources, omission of manufacturer's recommendations regarding corrosion information, source storage, inspection and testing, violation of International Atomic Energy Agency Radiation Protection Procedures, and lack of proper regulatory control, resulted in integrity damage to about sixty special form sources (ISO2919 C 63322), leakage of Cs-137 from a supposed insoluble refractory active content (caesium silicoaluminate), and contamination of applicators, floors and bedding.

When the situation was detected by means removal contamination tests, after routine inspections, the sources were removed from the hospitals, decontaminated by means of immersion in 3% EDTA solution in ultrasonic bath, subjected to leaking assessment tests, and the ones that passed were placed in low cost stainless steel source holders, designed and built by the Instituto Venezolano de Investigaciones Científicas (IVIC) returned to the hospitals. The leaking sources were removed from use and considered radioactive waste. In order to avoid the occurrence of similar situations, all the importers of such sources are now required to send them to IVIC for testing and placement in proper source holders, before they are shipped to the hospitals.

1. Introduction

During the 1980s in Venezuela the old Radium 226 braquitherapy needles and tubes were replaced with Caesium 137 sources. The first supply of such sources was received between 1982 and 1984, and corresponded to Nuclear Associates Inc. models 67-802 and 67-804. These models are considered the "old sources", and its source holders were purchased abroad. The second supply was imported during the 1985-1988 period, it consisted of Amersham International Plc models CDCS M4 and CDCS M2, these sources are considered the "new sources".

This second supply did not include the source holders recommended by manufacturer [1] [2] and were place in "Sondas de Nelaton", improper source holders locally manufactured from pieces of drainage plastic tubing, before being sent to the hospitals.

In the case of the new sources, it appears that neither the hospitals nor the national competent authority for medical applications of ionising radiation, Dirección de Ingeniería Sanitaria and Dirección de Oncología from the Ministerio de Sanidad y Asistencia Social (MSAS), Ministry of Health, received copies of the source certificates, medical source safety manual, and procedures for source cleaning, eventhought the Dirección General de Compras from MSAS purchased all the sources old and new and distributed them to the hospitals [3].

2. Detection of the contamination

On February 26 1993, during an annual quality control and calibration inspection of the Cobalt 60 Teletherapy unit, located at Hospital Oncológico Luis Razetti in Caracas, personnel from the IVIC's Secondary Standard Dosimetry Laboratory (LSCD), took samples for a removable contamination tests from the source storage area, source shieldings and exterior part of the source holders. Analysis of the samples clearly indicated the presence of contamination from Cs-137 [4].

3. Cause of the contamination

The "Nelaton" source holders, in which most of the Cs-137 sources were placed, are locally manufactured from pieces of drainage plastic tubing. The plastic material of such holders is polivinilcloride (PVC) [5].

It is thought that the radiation from the sources accelerated the degradation of the PVC, which produced hydrochloric acid HCl and chlorine gas Cl_2. These corrosive agents attacked first the double encapsulation of AISI 316L grade stainless steel, and after the encapsulation was lost the caesium silicoaluminate $Cs_2O.Al_2O_3.4SiO_2$ [2] creating a sort of gel that easily migrated to the outside of the sources, contaminating the source holders, applicators, bedding and floors [3].

Ten out of ten new sources placed in a different plastic source holder maintained their integrity. The plastic material of these source holders was a low-density polymer, not PVC [5].

The omission of manufacturer's recommendations regarding corrosion information, source storage, inspection and testing increased the damage to the sources, since for years the sources remained in the corrosive environment.

If the International Atomic Energy Agency Radiation Protection Procedures, established in Safety Series No. 38 [6] were followed, and sources tested every three months, the contamination would have been detected much sooner and remedial actions could have been more effective.

Lack of proper regulatory control was a very important factor in this situation. Before 1992 there was no control whatsoever of the imports of radioactive sources into the country. All the sources involved were imported during the 1980 and thus were not registered or controlled.

4. Remedial actions taken

As soon as the incident was identified the following actions were taken by personal from IVIC [5]:

- The contaminated sources were removed from the hospitals.
- The sources were cleaned by means of immersion in 3% EDTA solution in ultrasonic bath.
- After cleaning leaking assessment tests were carried out on every source.
- IVIC personal designed and built stainless steel source holders with the following characteristics [7]:
- Low cost.
- Proper materials found in the national market.
- Easy to build using simple tools.
- Easy to place sources in the source holder and this in the applicator.
- Low possibility of sources accidentally coming out of the holder.
- Good distance from the source to the operator's hand.
- Easy to remove the sources from the holders, without damaging neither one of them.
- The sources that passed the test, 90% of "old" and 36 % of "new sources", were placed in stainless steel source holders and where returned to the hospitals.
- The leaking sources were removed from use, declared radioactive waste and stored as such.

In order to avoid the occurrence of similar situations the Ministerio de Energía y Minas (Ministry of Energy) issues, since 1992, import permits with the condition that the importers of manual after loading intracavitary radiotherapy sources must send them to IVIC, as soon as they arrive in the country, for testing and placement in proper source holders, before they are shipped to the hospitals.

5. Public health consequences

The direct health consequences to patients from the contamination have not been determined, but the reduction of the number of intracavitary radiotherapy treatments created massive overcrowding of the services that remained functional, which resulted in serious difficulties within the country, and an undetermined number of patients were treated later than planned or not treated at all.

6. Conclusions

The causes of the incident were the use of improper source holders which deteriorated and created a corrosive environment all around the sources, omission of manufacturer's recommendations regarding corrosion information, source storage, inspection and testing, violation of International Atomic Energy Agency Radiation Protection Procedures, and lack of proper regulatory control.

The direct health consequences to patients from the contamination have not been determined, but the reduction of the number of intracavitary radiotherapy treatments created massive overcrowding of the services that remained functional.

After the incident a better source control and maintenance program was implemented in order to avoid the occurrence of similar situations, all the importers of Caesium braquitherapy sources are required to send them to IVIC for testing and placement in proper source holders, before they are sent to the hospitals. The effectiveness of these actions is now under evaluation.

It should be emphasised that this kind of situation can be repeated if sources are placed in corrosive environments and radiation safety procedures do not exist or are not followed and enforced.

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RADIATION SOURCES AND MATERIALS SAFETY AND SECURITY IN GEORGIA

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Abstract:

This paper explains the problems of safety and security in Georgia, the most important incidents and accidents, their consequences (including severe injuries and deaths) and governmental actions for prevention and mitigation.

XA9848211

1. Introduction

Disintegration of the Soviet Union and the economic system, and transition to the market economy negatively affected the infrastructure of radiation security in Georgia. A leakage of trained specialists working in the field of radiation security took place in Georgia; also personnel, apparatuses, devices and materials necessary for securing radiation.

Over the past years practically no radioactive sources were transported into Georgia and, because of the reduction of work in the different fields of industry and science, the sources which had been transported in the previous years were not used. This led to a relaxed attention to their storage. As a consequence of all this, emergency situations, dangerous to health and the environment, became more frequent.

2. Short description of the most important accidents

In fact, over the past seven years several radiation incidents took place in Georgia; the following being the ones that led to serious consequences:

- New Aphon, Abkhazia, 1992 - plundering and opening of the container which held the radium source. **Consequence - radiation pollution of the territory, and irradiation of two people.**
- Kutaisi, West Georgia, 1996 - plundering and opening of the container which held a powerful source of radioactive cobalt. **Consequence - Injury to 4 persons, one of whom died due to the acute radiation 3 weeks after the incident.**
- Lilo (near Tbilisi, the former Military Base of the Soviet Army, and now the Preparation Centre of the Department of Frontiers in Georgia), 1997 - this incident was widely discussed at the IAEA. Because of negligence and the absence of control, ampoules with radioactive czesi were stolen. The soldiers of this unit were irradiated, eleven of them with varying degrees of seriousness. Thanks to the aid of the IAEA, WHO and other international organizations, the soldiers lives were saved and the source was cleaned up.

3. Governmental actions

In Georgia today the following is being carried out in accordance with the programme of International Aid:

- *the regulation, based on legislation and norms in the field of radiation safety and* security;

- the establishment of a united structure of the governmental regulations for providing radiation security to the whole territory of Georgia;
- the formation of a system of control and monitoring of radioactive sources and the environment;
- according to the Government Programme, the monitoring of radiation sources in military bases (former and present) is being carried out for the whole of the territory of Georgia.

INTERNATIONAL CO-OPERATION, INCLUDING REPORTING SYSTEMS AND DATABASES

(Technical Session 5)

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THE IAEA's SUBPROGRAMME ON THE SAFETY OF RADIATION SOURCES AND THE SECURITY OF RADIOACTIVE MATERIALS

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Abstract

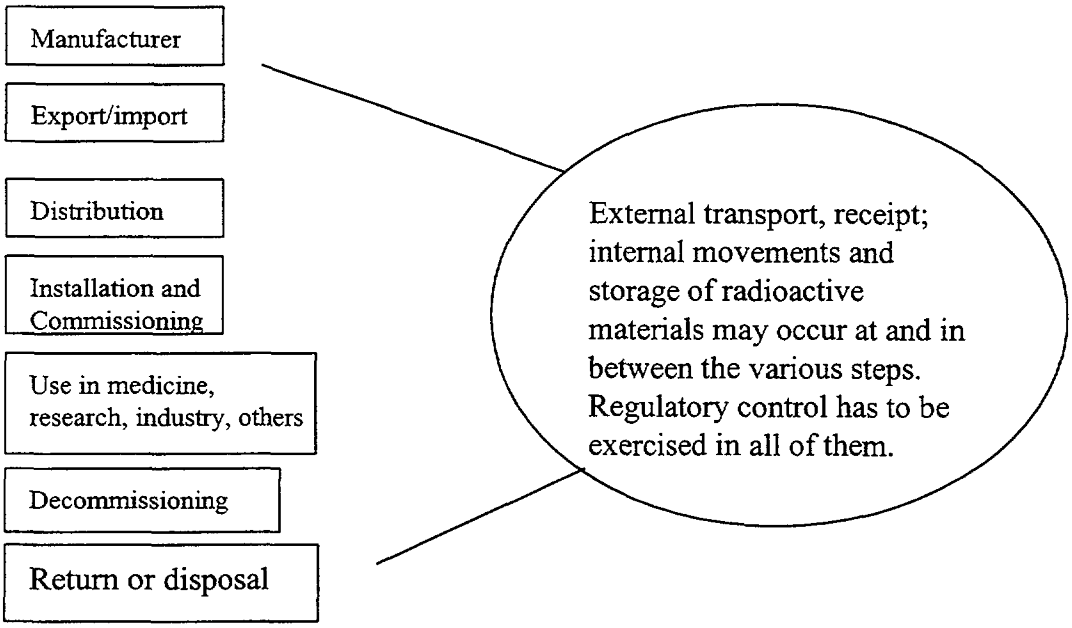
In compliance with its mandate to establish standards of safety and to provide for their application with respect to radiation sources, the International Atomic Energy Agency has developed a subprogramme aimed at providing Member States guidance and assistance on achieving regulatory control and the safe use of the sources. The guidance addresses the establishment of a Regulatory Programme, with focus on a system for notification and authorization (registration and licensing) and inspection of radiation sources, including check lists for review of safety. It also includes methods for assessing its effectiveness of the Regulatory Programme and is complemented with tools for the management of data by the Regulatory Authority and Services to assist Member States in assessment and implementation of the programme. In addition, technical guidance for the safety of radiation sources includes both prospective and retrospective safety assessment. Retrospective methods have been used resulting in the publication and dissemination of information and lessons from accidents, both individual accident reports and lessons from collection of accident for the practices with major sources (industrial radiography, irradiators and radiotherapy). Prospective methods will include guidance on the application of the principles of radiation protection to potential exposure, as well as methods to apply the principles, such as identification and evaluation of scenarios. Practice specific reports will address the major radiation sources. A research programme will be dedicated to apply Probabilistic Safety Assessment (PSA) to radiation sources.

1. Introduction

The statutory mandate requires the IAEA "... to establish standards of Safety... and to provide for their application ...". Concerning radiation sources, the standards of safety are established in the FAO/IAEA/ILO/NEA(OECD)/PAHO/WHO International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS)[1]. The BSS place requirements on registrants and licensees, who have, therefore, the primary responsibility for applying the Standards. Governments, however, have the responsibility for the enforcement, generally through a system that includes a Regulatory Authority; in addition governments, generally provide for certain services that exceed or that complement the capabilities of the legal persons authorized to conduct practices involving radiation sources. The Standards are based, therefore, on the presumption that a national infrastructure is in place enabling the Government to discharge its responsibilities for radiation protection and safety.

2. Regulatory infrastructure

The subprogramme described below, includes activities carried out in the recent years as well as activities planned until the end of the year 2000. In providing for the application of the Standards, the subprogramme addresses the establishment of the regulatory infrastructure in the first place. Provisions are to be made to assist in ensuring that no source escapes the regulatory control in any of the steps and between steps (see figure). This is achieved by compliance with BSS administrative requirements, i.e., by an effective system of notification and authorization (registration and licensing).



2.1. Development of the infrastructure

In a Provisional Standards Series [2], guidance is provided on how to optimize and integrate each element of a regulatory infrastructure with its other elements. The elements covered include regulations, authorization, exemption, inspection, enforcement, accident investigation and dissemination of information. More specifically, the system of notification and authorization, and the options for combining registration and licensing are discussed in terms of the number and size of radiation practices within the country, size of staff and its level of training, and the availability of expert consultant assistance. An example of legislation to establish a Regulatory Authority as contemplated in the BSS, and sample regulations based upon the BSS is also provided in an Annex.

Once the system has being designed, there is a need for advice on how to implement it. A draft Technical Document [3] describes methods and review plans to facilitate authorization inspection of radiation sources, including the preparation and conduction of an inspection and follow up action. The document includes annexes with practice specific checklists for safety review for authorization and inspection.

2.2. Assessment by peer review of effectiveness of a regulatory programme.

Appraisal of the effectiveness at the different stages of the organization and implementation of the programme is essential to correct weaknesses and optimize resources. a Safety Report [4] provides advice on conduction of peer reviews using a methodology and performance criteria and on how to obtain qualitative and quantitative information and its analysis against the performance criteria.

2.3. Regulatory authority information system

The management of the regulatory programme needs prompt and updated information on the location of radiation sources in the country, the facilities, on the authorization process, the inspection and enforcement actions, the dosimetry of occupationally exposed personnel and performance indicators both at level of individual installations and at national level. For

Infrastructure, described in another paper of the Conference, and is particularly efficient in the case of RAIS.

2.4. Advisory services on the regulatory control of radiation sources

As indicated in the previous paragraph, Member States may need assistance in appraising the status of their regulatory programmes and identifying regulatory programme weaknesses and in providing recommendations for improving implementation of the BSS. The subprogramme includes an Advisory Service to provide this assistance in form of peer reviews. The task of this review may also include to prepare or comment on the relevant legislation and regulations; prepare practice specific regulations and codes of practice; help optimize efficiency and effectiveness in the regulatory programme; and assist in conducting authorization reviews for complex, one of a kind, uses within the country, e.g., a large product irradiator.

Such Advisory Service to Member States may also help lay a foundation for greater regional exchange of information and mutual assistance on regional kinds of issues. In other words, this could be described as "regional networking" among professionals within national Regulatory Programmes.

3. Safety assessment

So far a description of organizational measures has been presented in this paper. The next step is to provide technical recommendation and advice on how to anticipate "what can go wrong" and to assess whether measures for prevention and mitigation. To carry out this task, two methods are available: prospective and retrospective methods.

Retrospective methods by feedback from experience have benefits and limitations: It is straightforward to use information about causes and consequences of actual accidents; it is easily understood by anyone and therefore is very useful to create awareness; preventive measures derived from lessons learned from accidents, drastically reduce the potential for future events.

The main limitation of retrospective methods is that lessons from experience are based on events known to have occurred, and therefore they may overlook potential accidents, i.e., accidents that were not reported or potential accident that did not occur yet. On the other hand, prospective methods put possible accident scenarios in perspective in a systematic way, and by quantification of probabilities, identify weaknesses, even if they never manifest in an accident.

Both methods are part of the subprogramme as described below.

3.1. Retrospective safety assessment

The Agency has investigated some of the accidents and collected information of others. The information is disseminated in two ways: in form of reports of individual accidents and of lessons from a large number of practice specific collection of events.

Report of individual radiological accidents have been published: Goiania, El Salvador, Soreq, Hanoi, Nesvizh,. The following are in preparation: Tammiku, San José de Costa Rica (in press), Iran and Georgia (in preparation) [5-10].

Three reports have been prepared on practice specific lessons learned from accidents: industrial irradiators (eight events), industrial radiography (43 events) and radiotherapy (93 events). In addition a draft Safety Guide on the Safety of Radiation Sources provides guidance to meet the BSS principal requirements and the detailed requirements on the safety of sources, based primarily on the feedback from operational experience. The guide covers all practices and addresses the design and operation of sealed and unsealed sources and radiation generators.

Finally, a continuing activity to collect further information from experience, consists of an International Reporting System of Unusual Radiation Events (RADEV); the system is expected to benefit from and to Member States and professional associations.

Guidance on a systematic approach for investigating accidents involving radiation sources and deriving lessons learned has been prepared (final draft)[11]. The methodology includes categorization of accidents, investigation team composition; organization, planning and conduct of the investigation; data collection and analysis; content of a formal investigation report; and dissemination of information.

3.2. Prospective safety assessment

To comply with the BSS requirements on protection against potential exposure, a Safety Guide has been included in the subprogramme. The document will provide guidance on application of the principles of protection to potential exposure, methods to identify and perform an assessment of scenarios; it finally will provide examples of application of the principles to selected scenarios.

The Guide will be supplemented by practice specific Safety Reports in which prospective assessment to major specific sources will be applied: three reports are planned for the following sources: industrial irradiators, industrial radiography, and radiotherapy.

The subprogramme includes encouraging research and development by investigating methods and procedures to apply Probabilistic Safety Assessment (PSA) to major radiation sources; developing tools for implementing procedures to apply PSA to radiation sources and specifying data requirements for PSA application and methods of data collection.

4. Training

The programme includes training manuals, practical radiation safety manuals and visual aids on the subject described above for use in training events for the development of manpower in Member States. The events may be interregional, or regional, usually organized by the IAEA and national, usually run by the country.

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QUALITY ASSURANCE FOR DIAGNOSTIC X-RAY MACHINES IN TANZANIA

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Abstract

In this presentation it is being discussed a close relationship between the prevention of accidents involving apparatus that generates the ionizing radiation(x-ray tubes etc) and the need to perform quality control procedures and make follow-up corrective maintenance procedures. A summary of results of quality control performance of x-ray machines in certain centers in Tanzania is tabled and measures to overcome some of the observed problems are recommended. The number of X-ray units inspected were 219, out of which 123 were working, 75 were out of order, 6 units were not yet installed and those which are working with faulty parts were 15. The performance of quality assurance for X-Ray units (57) tested showed that 36.8% didn't qualify. About 80% of these equipment are more than 15yrs old.

1. Introduction

Quality control procedures on an x-ray machine are routine measurements of physical parameters of various components of the equipment. Quality administration in the x-ray machine is the management of the quality control procedures, this includes making sure that the equipment monitoring and performance evaluation is properly done, assessed and recorded. It also involves following up with necessary corrective measures [1],[2]. The diagnostic X-ray units in Tanzania is still very much affected by inadequate management in terms of quality control and preventive maintenance. Many of these equipment are functioning incorrectly or are inoperative altogether, because of a lack of proper maintenance services. Qualified service staffs are not available or expensive especially if are from Manufacturers/suppliers from overseas. Lack of service manuals and spare parts is another bottleneck. The situation is even more worse due to financial constraints to quarantee performance of quality control and preventive maintenance procedures let alone repairs. For these reasons the quality control procedures are not carried frequently and follow-up action like corrective maintenance, recalibrations and repairs are not done.

In view of this situation, NATIONAL RADIATION COMMISSION, (Regulatory Authority in Atomic energy matter in the Country) through its Nuclear Instrument maintenance section, with the assistance from INTERNATIONAL ATOMIC ENERGY AGENCY carried out quality control and Preventive maintenance programme for nuclear and related medical equipment, particularly x-ray machines in the country. The program of work was to establish an inventory, assess status of equipment, performance of quality control and Preventive maintenance, assess the local maintenance capabilities and skilled manpower and prepare the report on the observed problems and make recommendations.

2. Methods

During the survey of these equipment, we carried-out QC procedures, of which due to several reasons only four types of tests were carried out. These are:-kVp calibration, Timer accuracy , collimator/beam alignment checks and tube leakage test. Even these few were not performed every time because either the equipment to be tested were completely out of order; had some faults like, light beam diaphragm or the films or film processing chemicals are lacking. Some units did not meet the required specifications for certain quality control procedures (e.g a coned diaphragm does not meet specifications for timer or kVp test).Also unavailability of some test/monitoring instruments during survey work prohibited some quality control procedures to be done [3]

2.1. Beam alignment and collimation.

The RMI beam alignment tool (Model 161B) and collimation test tools were used. The placement of collimator and beam alignment test tool done according to RMI quality assurance handbook. The radiograph done on the 8" x 10" cassette. The exposure parameters to give good picture were selected accordingly.

2.1.1. Collimation; If the X-ray field falls just within the image of the rectangular frame there is a good alignment. E.g., if the edge of X-ray field falls on the 1st spot ,+-1cm on either side of the line, it shows that X-ray and light field is misalign by 1% of the distance between the X- ray source and the table. The maximum allowable misalignment is 2% of the source to image distance, (S.I.D).

2.1.2. Beam alignment; *The X-ray beam should be perpendicular to the plane of the image* receptor. If the images of the two steel balls on the test tool overlap the central ray perpendicularly or within 1.5^0 away it is acceptable.

2.2. KVp tests

The tests are done as indicated on the RMI quality assurance handbook. The Instrument used is digital KVp meter, model 230. The exposure parameters were to be selected depending on whether the equipment is single or three phase unit. For single phase, time selected were > 0.2sec, mA > 20mA for radiograph and for three phase units, time set were >0.1sec. Three different KVp stations tested and data collected to each unit.

2.3. Timer test

The test for timer accuracy was done by RMI, digital X-ray exposure timer, model 231A.The source-detector distance set at 100cm for three phase unit and 75cm for single phase unit. The adjustment of beam limiting device to produce an X-ray field at the detector of about 2.5cm square done. In most cases the technique factors used were 80KVp, and 200mA and three settings of timer tested.

2.4. Tube leakage test

The leakage measurements for the X-ray tube for two X-ray units was done at 100cm, FDD positions at four different sides of the tube. The operating parameters during the leakage tests were 125KVp, and 250mAs for both units. Instrument used is Bethold dosimeter model LB 1310, S/no; 602-0405 with X/T probe model KZ25P, S/no; 3162.

3. Results and discussions

Misalignment of the light field and the x-ray field is a common problem for x-ray units surveyed. About 40% of the units tested indicated that the x-ray and light fields are misalign by more than 2% (-+ 2cm) which is unacceptable [3]. However in most of cases the problem was rectified by the maintenance personnel of the research team. The x-ray beam in some units also showed the central ray is more than 3 degrees away from the perpendicular although they are few units misalign to that extent (see table 1) In some Hospitals, the faulty beam alignment and collimation devices were dismantled and radiograph were done without it which pose unnecessary exposure to the patients.

About **50%** equipment tested **for kV calibration** showed unacceptable errors ranging from 4kV to 20kV. For example *Sumve hospital in Mwanza region* showed a kV error of +20kV well above the acceptable error of -+ 4kVp [3].

Some equipments showed variation above the acceptable errors in the timer tests. e.g. at Muhimbili medical centres SIEMENS HELIOPHOS 4, set time was 1.00 sec, recorded time was 1.689 sec an error of 0.689 sec. Erroneous timing reading may be caused by wave form problems, for example, pulses of different height, too low radiation intensity or low peak intensity at the beginning of exposure and faulty timing circuit. It is suggested the error be limited to +-5% or 2msec, which ever is large [3].

Most of these units are very old and no any preventive maintenance being done. This facilitated the deterioration and bad performances. In some equipment the selection of some exposure techniques were not possible due to bad contact at KVp or mA selection contacts plates. The contacts plates were burnt. Some of these equipment were being operated by unqualified persons which lead to bad and carelessness handling. This is justified by the findings that 11 X-ray tubes for the mobile/portable diagnostic X-ray units were out of order. The damage which mostly might be occurred during moving from one room to another doing radiograph.

The break systems for the X-ray tube movement and positioning is common problem recorded. Some radiographers use wooden bars to support and positioning the tube during taking radiograph. This is dangerous, it may cause both physical injuries accidental radiation overexposure to the patients.

Table. 1 Results of quality control performance for various X-Ray units

Quality control test	ACCEPTANCE		Total units tested
	YES	NO	
Kilovoltage	11	11	22
Timer	14	5	19
Beam alignment & collimation	11	5	16
Leakage tests	2	0	2

3.1 Leakage test,

The results were below 0.5mSv/hour at 1m and are as shown below, see table 2. Both X-ray units complied with safety requirement. [2]

Table. 2; Leakage measurements obtained in the horizontal plane of X-ray tube.

Direction about the tube position	Philips X-ray unit,(Model Medio 50CP)	Shimadzu circlex P 13C
West	0.28 +- 0.04 mGy/hour	0.33 +- 0.04 mGy/hour
East	0.36 +- 0.08 mGy/hour	0.22 +- 0.03 mGy/hour
North	0.19 +- 0.01 mGy/hour	0.19 +- 0.01 mGy/hour
South	0.11 +- 0.01 mGy/hour	+- 0.04 mGy/hour

4. Conclusion

The prevention of accidents involving apparatus that generates ionizing radiation basically entails all aspects related to quality assurance, preventive maintenance, corrective maintenance as well as safe and proper operation of the apparatus hence requirement for skilled and qualified operating and maintenance staff. Establishment of co-ordination between personnel who perform

QC procedures and service agents who are supposed to perform the corrective maintenance is vital. It should be noted that QC, PM and repairs are integral procedures in that way complementary to radiation protection procedures. During the installation of these equipment, the initial quality control compliance tests should be done with periodical tests and corrective measures thereafter. It should be taken as mandatory for manufacturers to establish the servicing agents with necessary spare parts for their equipment. They can train some technicians from already established workshop/institutes in the country, who will be servicing agents. All manuals should be available to the users and service technicians. At present due to the problems pointed out earlier there is no follow up action on the QC results particularly, in corrective maintenance aspect.

In design aspect it is suggested that the manufacturers to include both **automatic and manual break systems** to the X-ray machine so that if one system fails other option can be used.

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APPROCHE ET ORGANISATION DE LA SURETE DES SOURCES RADIOACTIVES ET DE LA SECURITE DES INSTALLATIONS

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Résumé:
Les applications des techniques utilisant des sources de rayonnements ionisants connaissent un développement accru dans tous les domaines socio-économiques. Bien que ces techniques sont destinées à des applications dites pacifiques, elles doivent néanmoins respecter les règles de sûreté afin d'assurer la sécurité des travailleurs, du public des installations et de l'environnement.
Le système de sécurité des installations adopté par le CNESTEN se base sur la mise en place de barrières tant administratives que techniques pour assurer d'une part la protection des installations contre les agressions externes et internes, et d'autre part, la protection de l'environnement par le confinement de la radioactivité.
L'application de la Méthode Organisée et Systématique d'Analyse de Risques (MOSAR) aux installations du CNESTEN a montré les points faibles afin de définir les barrières de prévention et les moyens d'intervention nécessaires à la gestion et à la maîtrise des situations accidentelles. Dans ce premier stade, cette étude s'est limitée aux considérations qualitatives en adoptant une analyse macroscopique de chaque installation. Le retour d'expérience de fonctionnement de ces installations, qui ont démarré leurs activités à peine quelques mois, constituera une véritable source de données indispensables pour compléter l'analyse des risques en incluant les quantifications possibles de ces risques

1. INTRODUCTION

Durant les années quarante, les applications des techniques utilisants des sources de rayonnements ont été introduites au Maroc dans le domaine médical et l'agriculture. La prise en compte par la communauté scientifique et industrielle de l'importance des applications bénéfiques des sources de rayonnements s'est manifestée par le développement de ces applications dans différents secteurs socio-économiques tels: l'industrie, la médecine vétérinaire, la recherche scientifique et l'enseignement, la géologie, l'environnement. [1]

2. CADRE INSTITUTIONNEL ET REGLEMENTAIRE NATIONAL

L'étendue des domaines utilisant les sources de rayonnements a fait réagir les pouvoirs publics pour mettre en place un cadre réglementaire adéquat renforçant davantage le rôle de l'Etat dans les opérations de contrôle afin d'assurer la sécurité du public et la protection de l'environnement contre les risques inhérents à l'utilisation des sources de rayonnements. Des structures institutionnelles, à mission nationale de coordination, de contrôle ou d'appui technique et dotées de moyens nécessaires à l'exercice de la mission de contrôle de l'Etat, ont été créées, notamment [2]:

- le Conseil National de l'Energie Nucléaire (CNEN): structure consultative de coordination,
- le Ministère de l'Energie et des Mines: autorité nationale en matière de sûreté nucléaire,

- le Ministère de la Santé, par le biais du Centre National de RadioProtection (CNRP): autorité nationale en matière de radioprotection,
- le Centre National de l'Energie, des Sciences et des Techniques Nucléaires (CNESTEN): organisme opérationnel et appui technique de l'Etat en matière de sûreté nucléaire.

De part leurs missions et attributions, ces différentes institutions ont contribué avec les départements ministériels concernés à arrêter les orientations nationales dans le domaine de l'utilisation des techniques nucléaires, et définir les principaux objectifs du cadre législatif dans lequel sera réglementé le développement de ces applications.

Le processus d'élaboration du cadre réglementaire national a pris en compte dans la démarche suivie, les engagements internationaux auxquels a souscrit le Maroc en vertu des conventions et traités. Les principaux textes de la réglementation nucléaire nationale sont:

- la loi relative à la protection contre les rayonnements ionisants;
- le décret relatif à l'autorisation et au contrôle des installations nucléaires;
- le décret pris pour l'application de la loi relative à la protection contre les rayonnements ionisants;
- le décret relatif à l'utilisation des rayonnements ionisants à des fins médicales;

D'autres textes réglementaires sont à l'état de projets, et notamment:

- le projet de décret relatif à la gestion des déchets radioactifs;
- le projet de décret relatif à la responsabilité civile en cas de dommages nucléaires;
- le projet de décret relatif au transport des matières radioactives;
- le projet de décret relatif à la protection physique des matières radioactives.

Cependant, les textes réglementaires traduisent le plus souvent, les préoccupations des pouvoirs publics en terme d'objectifs généraux à atteindre. Sur le plan pratique, la réglementation impose à l'exploitant d'une installation de mettre en oeuvre toutes les dispositions techniques et administratives à même d'assurer le respect des objectifs arrêtés par les textes réglementaires et des normes standards des règles de l'art et de la bonne pratique.

3. ROLE ET ACTIVITES DU CNESTEN

La principale mission confiée au CNESTEN est la promotion de l'utilisation des techniques nucléaires dans les différents secteurs socio-économiques du pays [3]. Les installations actuelles du CNESTEN sont constituées de laboratoires à vocation scientifique dont les activités utilisatrices de sources radioactives remplissent les fonctions suivantes:

- la collecte et l'entreposage de sources radioactives usées à l'échelle nationale,
- les analyses élémentaires par des techniques nucléaires: fluorescence X, spectrométrie gamma, spectrométrie alpha, scintillation liquide,
- le contrôle non destructif par la technique de radiographie gamma à l'aide d'un projecteur gamma doté d'une source d'Iridium 192 et d'une activité nominale de 80 Curies,
- les techniques de traçage radioactif et l'utilisation des jauges radiométriques,
- la préparation de radio-isotopes à usage médical ainsi que les kits radio-pharmaceutiques.

A moyen terme, les installations du CNESTEN seront renforcées par un réacteur de recherche de type TRIGA Mark II et d'une puissance nominale de 2 MW, avec des laboratoires remplissant les fonctions de support et de recherche associées au réacteur.

4. LE SYSTEME DE SECURITE AU CNESTEN

Le système de sécurité des installations adopté par le CNESTEN se base sur la mise en place de barrières tant administratives que techniques pour assurer d'une part la protection des installations contre les agressions externes et internes, et d'autre part, la protection de l'environnement par le confinement de la radioactivité.

Les barrières d'ordre administratif peuvent se résumer en:

- l'application des dispositions réglementaires exigées par le Ministère de la Santé sur le plan de la protection radiologique. Ces dispositions concernent notamment le régime des autorisations régissant l'importation, le transport et l'utilisation de sources radioactives. De plus, la réglementation exige que le personnel affecté à manipuler les sources radioactives ait les qualifications requises pour faire face à toutes les conditions de fonctionnement.
- la mise en place d'une organisation interne dédiée à la sûreté radiologique des sources de rayonnements et à la sécurité générale. Cette organisation définit les missions et les responsabilités de la Direction, de l'Ingénieur Sécurité, des Chefs d'Installations, des Animateurs de Sécurité, des Agents de Radioprotection, de l'Unité de Gardiennage et Secourisme.

Dans ce cadre, le CNESTEN a élaboré des documents de sécurité tels:

- le manuel de sécurité regroupant les procédures organisationnelles de la sécurité au sein des installations, les consignes de sécurité dans les laboratoires, ainsi que l'organisation de l'intervention en cas de situation accidentelle,
- le règlement interne de radioprotection,
- les consignes de radioprotection adaptées à chaque poste de travail.

Une attention particulière est accordée à l'effort de formation et d'information à tout le personnel du CNESTEN afin d'assurer une meilleure diffusion des missions des responsables hiérarchiques et des responsabilités de tout un chacun et de permettre l'adhésion de tout le personnel à un système de valeurs culturelles sur le plan de la sécurité et la sûreté.

En outre, le CNESTEN accorde une grande importance à la gestion des situations accidentelles. Un schéma d'organisation de crise a été élaboré et mis en application en prenant en considération le principe de l'astreinte pendant les heures et les jours non ouvrables. De plus, des scénarios hypothétiques de dysfonctionnements ont été étudiés pour définir les actions immédiates à entreprendre sous forme de fiches réflexes.

Dans le souci de l'amélioration de l'organisation interne prévue en cas de crise, des exercices de simulation sont mis en oeuvre afin de tester et de valider cette structure.

Les barrières d'ordre technique consistent en la mise en œuvre d'une méthodologie systématique d'analyse de risques. Les objectifs recherchés sont, d'une part prendre des mesures préventives pour détecter les situations incidentelles ou accidentelles, et d'autre part engager des actions correctives ou améliorations pour que ces situations anormales ne puissent plus se reproduire. Pour atteindre ces objectifs, l'étude de sécurité doit considérer toutes les sources de dangers radiologiques et classiques.

Des méthodes d'analyse de risques ont été mises au point afin d'aider l'exploitant de disposer d'un modèle caractéristique de la sécurité de fonctionnement de son installation [4]. On distingue généralement deux types de démarche dans l'analyse de la sûreté de fonctionnement d'un système, l'inductive et la déductive.

La méthodologie d'analyse de risques adopté par le CNESTEN est une démarche a deux composantes distinctes: inductive et déductive. En premier lieu, la démarche inductive est mise en oeuvre dans le cadre de l'analyse prévisionnelle de l'état de la sûreté et de la sécurité des installations. En second lieu, à l'occasion d'incidents ou tout simplement des exercices de simulation, la démarche déductive est appliquée pour réaliser les enquêtes et les analyses nécessaires afin de retrouver les causes de l'incident.

La combinaison des démarches inductives et déductives permettra de bénéficier d'un retour d'expérience propre à chaque installation afin d'améliorer l'efficacité de l'analyse prévisionnelle de la sûreté et de la sécurité de fonctionnement.

Dans ce cadre de travail, une étude de sécurité a été réalisée conjointement avec le Commissariat à l'Energie Atomique (CEA) français, en mettant en oeuvre la Méthode Organisée et Systématique d'Analyse de Risques (MOSAR) [5]. Cette méthode d'audit de la sécurité se déroule en cinq étapes:

a) Elaborer une cartographie des risques existant dans les installations en identifiant les sources de dangers (origines mécaniques, électriques, chimiques, de rayonnements, biologiques, dues à l'action de l'homme, dues à l'environnement) et les risques qu'elles entraînent pour les cibles qui pourraient en subir un dommage (à l'aide d'une grille d'analyse).

b) Evaluer les conséquences de ces risques sur les cibles qui sont de quatre types: le personnel, l'installation, les populations et l'écosystème.

c) Se fixer des objectifs de sécurité, à partir de la connaissance de la gravité et de la probabilité d'occurrence des accidents, afin de déterminer les risques acceptables au cours de la vie de l'installation (sachant que le risque zéro n'existe pas).

d) Définir les barrières de prévention (pour diminuer la probabilité d'occurrence des accidents) et de protection (pour diminuer la gravité de l'accident). Ces barrières doivent être qualifiées pour vérifier qu'elles sont fiables et qu'elles n'apportent pas elles-mêmes de sources de dangers. On considère:

   - la conception des installations, la ventilation, les postes de travail;
   - les questions de formation et de qualification du personnel;
   - les aspects techniques de maintenance, contrôles, surveillance;
   - les aspects réglementaires;
   - l'ergonomie des postes de travail;
   - les barrières à adopter pour protéger l'environnement et se protéger de l'environnement.

e) Gérer les risques résiduels, c'est-à-dire se préparer à la conduite de l'installation en cas de situations accidentelles en intégrant la sécurité dans les opérations d'intervention et de réhabilitation.

Les résultats de la méthode MOSAR, appliquée aux laboratoires du CNESTEN, sont présentés sous forme de tableaux par laboratoire [6]:

Nature du risque			
Points faibles Sources de dangers	**Localisation**	**Effets & Quantification**	**Mesures de prévention**
♦ identification de sources de dangers; ♦ apparition possible de flux de dangers	♦ lieu de l'observation.	♦ effets sur les cibles; ♦ quelques quantification possibles.	♦ modifications; ♦ améliorations; ♦ points à corriger; ♦ consignes à appliquer
point a	**point b**	**point c**	**point d**

Le **point e** concernant la gestion du risque résiduel, consiste à prendre les dispositions nécessaires d'intervention pour limiter les effets des accidents. Dans ce cadre, des exercices de simulation de crise, à partir des situations dangereuses identifiées au cours de l'analyse, seront organisés afin de valider et vérifier l'efficacité des dispositifs d'intervention envisagés.

En conclusion, l'étude de sécurité réalisée a montré les points faibles des installations ainsi que les actions correctives à entreprendre. Dans ce premier stade, cette étude s'est limitée aux considérations qualitatives en adoptant une analyse macroscopique de chaque installation. Le retour d'expérience de fonctionnement de ces installations, qui ont démarré leurs activités à peine quelques mois, constituera une véritable source de données indispensables pour compléter l'analyse des risques en incluant les quantifications possibles de ces risques.

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AWARENESS, TRAINING, EXCHANGE OF INFORMATION AND CO-OPERATION AMONG REGULATORY AUTHORITIES AND OTHER LAW ENFORCEMENT INSTITUTIONS – EXPERIENCE AND PROBLEMS IN LATVIA

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Abstract

Latvia is developing infrastructure to ensure adequate system for safety and security of radioactive and nuclear materials, radiation sources and nuclear facilities within its Radiation and Nuclear Safety legal framework. The first phase of implementation was to establish and develop further relevant legal acts, but in the same time there was a need to improve the technical capabilities for the control of goods movement across the border and the need to establish the relevant educational system. The Ministry of Environmental Protection and Regional Development (MEPRD) started to participate in this process from the early beginnings when the problem of illicit trafficking was foreseen. After the technical expertise carried out by the Environmental Data Centre the first border guards and customs control points were equipped with portable measurement devices. By assistance of Nordic countries and USA this system is under constant development, but full scope conceptual analysis of entire problem is not yet finished. The need for further development of the training capabilities, as well as information sharing among all relevant institutions and awareness building for decision-makers still remains.

1. Introduction

The security and safety of radiation sources (including radioactive materials, nuclear materials, all other type of man-made sources of ionising radiation) are closely linked to the illicit trafficking phenomenon. There are two main tasks:

- To ensure that all radiation sources belonging to the entities in the country are under state control, the illicit movement of them (non-authorised activities) has to be detected in the early stages.
- To ensure that cross-border movement of any such source is under control, undeclared materials have to be stopped at the border.

The rapid changes in political and economical systems in late eighties and early nineties increase the severity of this problem. Definitely it is not a new phenomenon and the radiological accident in Brazil – Goiania serves as a good example. But the amount of incidents where the control over the sources at the facilities was lost and the increase of smuggling events with radiation sources are significant enough to draw the attention of the society towards the radiation safety. As a proof, one can refer to joint activities of the IAEA and several international organisations in drafting the new Basic Safety Standards [1] where Safety of Radiation Sources was included even in the title of this document.

2. Implementation of safety fundamentals for safety of radiation sources in national legislation

Law "On Radiation Protection and Nuclear Safety" is the basic document for implementation the radiation protection and nuclear safety objective [2]. The purpose of the

Law is to protect people and the environment against harmful effects of ionising radiation. Article 11 of the law prescribes the necessary actions for ensuring the supervision:

- Job supervisors shall provide with all necessary information to the Radiation and Nuclear Safety Inspectorate (RNSI),
- The police shall provide the assistance necessary for the purposes of supervision,
- Customs services shall control the import, export of radioactive substances and nuclear materials, and provide with necessary information to the RNSI concerning the transfer of such substances and materials across the state borders.

Those provisions serve as the basis for sharing responsibilities between authorities, and establish the primary scheme for exchange of information.

For the further securing of adequate awareness system for safety and security of radioactive and nuclear materials the law was amended with new term "undeclared ionising sources". This term clarifies the issue and is essential for customs Services and border guards.

Specific requirements for physical protection, that the facility shall meet before licence application for any activities with radiation sources were incorporated in the Regulations of the Cabinet of Ministers "On Issuance of Licences and Permits for Activities with Radioactive Substances and other Ionising Radiation Sources" [3]. Chapter IV establishes the requirement – "in order to obtain a licence or permit, the physical protection of materials or facilities shall be ensured first". These Regulations also establish the system for authorisation and accountancy of sources, which is a vital element to ensure State control over location of sources.

The Regulations on Protection against Ionising Radiation [4] (national BSS) Chapter III "Defence System, Requirements and Programs" determine the obligation to create an accounting system for all radiation sources and introduces technical safety requirements including "defence in depth" as well as some specific issues for physical protection.

The Regulations on State Accounting and Control System of Nuclear Materials [5] are based on EU Regulations 76/3227/Euratom [6] and Latvia's-IAEA Safeguard Agreement.

It is not surprising, that new draft Regulations on Safe Transport of Radioactive Materials [7], which are based on IAEA ST-1 [8] have several articles on physical protection.

To establish a legal system for border control, the Cabinet of Ministers has accepted specific regulations for dosimetric control [9]. As a matter of fact sufficient expertise and experience in this field was not available before, for this reason the MEPRD had drafted the new (significantly improved) version for this document. This draft incorporated questions about staff training, technical requirements for measurement devices, reporting system and information circulation [10].

3. Preventive measures against ilicit trafficking on the borders

According to the Cabinet Regulations on system for dosimetric control the border guards have the responsibility to detect undeclared movement of radiation sources across the national borders. To fulfil this obligation they definitely need adequate technical capabilities and relevant training. To characterise the situation in Latvia, it has to be noticed that all border-crossing points are equipped with portable dose meters, but only part of all highways across to the borders are equipped with stationary monitoring gates. The Riga's international airport has some portable devices; the border guards are using portable measurement devices to control harbours and railroads. There are two movable laboratories, besides several institutions can be involved in examination of the discovered smuggling objects or found lost sources.

The training of border guards in first stages were managed by international assistance, namely Swedish Radiation Protection Institute (SSI), USA Department of Energy (DOE), Finish Radiation Safety Authority (STUK). These activities mainly were under umbrella of bilateral co-operation or IAEA Co-ordinated Technical Support Plan for NIS. Staff of the Latvian Nuclear Research Centre was directly involved in the training activities for border guards organised by the USA.

What are the following steps after disclosure of undeclared radiation sources in cargo or personal property on border? This is where the activities of customs officers should begin, because according to the Customs Law, only customs officers may investigate the cargo. This part of activities on border still needs to be improved because there are certain technical issues related to organisation of control, especially for railroad, and in some cases also for cars and ships or aircrafts. This issue was taken for considerations during drafting of working procedures. The Government established a working group, which analysed the arrangement for implementation of border control system. The experts from border guards, Customs, transport administrations from different branches, police and radiation safety authorities were involved in these activities.

The training for customs officers is arranged in the Customs Institute jointly with the Technical University. The main activities for improvements of the staff training for both institutions – Border Guards and Customs are oriented to improve the capacity of the teachers as the less expensive and most sustainable option. Principle "train the trainers" is widely used in many fields, especially it is relevant for border guards because only a part of them are professionals, the majority of the them are in this position only during their state service time.

A smuggling case in Ludza (small city close to border with Russia) can serve as a practical example of working system. In April 1996 a group of people was discovered who had illegally imported low enriched uranium with intention to sell in "black market" in West countries. After the investigations two persons were prosecuted and imprisoned.

4. Preventive measures against ilicit trafficking inside of country

As it is shortly described above – the legal infrastructure is based on Law and regulations of the Cabinet of Ministers. According to the main principles the owner of source has responsibility for implementation of all relevant requirements. Taking into consideration that the owner himself may not be the expert in radiation safety, the key person for radiation safety is "job supervisor". For facilities with large sources or significant amount of smaller sources the national BSS requested to ensure adequate number of radiation safety experts. For same facilities with extensive use of radiation sources BSS requests to establish specialised radiation safety divisions.

University of Latvia usually arranges the post graduate training, but specific training on physical protection of nuclear facilities up to now is not available in Latvia. Under USA DOE support program one training event was arranged for staff of Nuclear Research Centre and subordinated institutions of Ministry of Environmental Protection and Regional Development. Only few Latvian experts received training under IAEA-USA DOE programmes in this field.

5. International co-operation

The main activities for improvement of safety and security of sources are under umbrella of IAEA Co-ordinated Technical Support Plan for NIS. The main donor states for Latvia are Sweden, USA and Finland. Some activities were described above, therefore only some major events have to be mentioned:

- Physical protection upgrades at the Nuclear Research Centre,
- Installation of the Radiation monitoring gates on the East borders of Latvia,
- Installation of the Radiation monitoring gates on the main transit highway "Via Baltic".

Further activities are related to Latvia's participation in the IAEA Illicit Trafficking Database program. The Ministry of Environmental Protection and Regional Development is the national co-ordinator of these activities. All received relevant information is transmitted to the Ministry of Interior (Security Police) and Customs Board.

The Swedish Nuclear Power Inspectorate (SKI) initiated further action plan for improvement safety and security of sources. Certain activities will be under technical support program, but also all-relevant institutions in Latvia will be involved in this program. First major event shall be a joint workshop of Swedish, Norway, Latvian and Finland experts together with top-level State officials from relevant ministries. During the two days meeting participants shall have to assess problems and work out the basis for conceptual action plan. Such procedure should also raise the awareness of decision-makers about the needs to improve the situation and apparently will facilitate the further co-operation among institutions and also neighbouring states.

6. Conclusions and main activities for future

The job supervisors at the facilities play the major role for the stabilisation of the system inside the country, only then the State can improve the situation by its well-developed supervision system. To achieve this goal any reasonable actions must be taken to develop the Safety Culture at the top level in the state. Regulatory bodies have to use all available methods to transmit and explain information about potential impact of the "lose of control over the radiation sources". This task is of utmost importance for the states in transition to a market economy, because Parliaments and Governments of these states have specific priorities in this period, but the past experience is not adequate with the present situation. A state with stable political and economic situation may find it much easier to increase the financial and manpower resources to prevent illicit trafficking for relatively short period of time. Moreover usually the private business facilities already have established the necessary security procedures and State institutions have sufficient power for the enforcement measures.

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ETAT ACTUEL ET PROGRAMME DE MISE A NIVEAU DES MECANISMES DE SURETE DES SOURCES EN TUNISIE

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Abstract

In Tunisia there is no research nor power reactor programme. All the equipment and sources of ionizing radiation are imported.

In order to ensure the radiation protection and sources safety, a legal infrastructure and a regulatory authority have been implemented since 1981.

The National centre of radiation Protection (CNRP) is entitled to authorize and inspect ionizing radiation practices and facilities.

A guidelines book is available to provide the administrative and technical procedures concerning licenses and controls of sources.

A central collection data related to equipment, users and intervening parties of ionizing radiation is available and updated.

The review of the radiation safety programme leads us up to complete it by adoption of new regulation in relation to new recommendations of ICRP, radioactive transport and waste management.

For the guarantee of safety prescriptions, a continuous training must be developed and culture of safety and radiological protection for the staff and the users must be introduced.

The estimate of this safety infrastructure should be regular.

Resume

La Tunisie ne possédant ni réacteur de puissance ni réacteur de recherche, importe de l'étranger tous les équipements et sources émettant des rayonnements ionisants.

Afin d'assurer la protection radiologique et la sûreté des sources, un dispositif juridique et un cadre institutionnel ont été mis en place depuis 1981.

Le Centre National de Radio-Protection (CNRP) autorise et inspecte les activités mettant en œuvre les rayonnements ionisants. Les procédures administratives et techniques concernant les autorisations et les contrôles sont consignées de façon claire dans un manuel de procédures et dans un guide de bonnes pratiques.

La centralisation de toutes les données relatives aux équipements comme aux institutions utilisatrices et aux personnes intervenantes dans le domaine permet d'avoir une base de données continuellement réactualisée.

La revue de notre système montre qu'il y a lieu de le compléter par l'adoption de nouveaux textes réglementaires actuellement en cours d'élaboration (nouvelles normes, transport, déchets).

La garantie du respect des prescriptions nécessite un effort continue de formation, d'information et de sensibilisation selon la population cible.

L'évaluation de ce système de sûreté doit être faite de façon périodique.

Aux fins de l'application des Normes Fondamentales Internationales, nous avons été amenés à faire l'analyse de notre système de protection radiologique et de sûreté des sources.

Nous présentons cette analyse dans le cadre de la Conférence Internationale sur la sûreté radiologique des sources et de la sécurité des matières radioactives.

La Tunisie ne possède actuellement ni réacteur de puissance, ni réacteur de recherche. Cependant, différents domaines : médical, industriel, agricole, et celui de la recherche ont recours aux sources de rayonnements ionisants qui, toutes, sont importées.

1. Etat actuel des moyens de surete radiologique

En Tunisie, les moyens actuellement en place en matière de sûreté radiologique sont les suivants :

1.1 Un dispositif juridique

Basé sur les principes de la justification des pratiques et de l'optimisation de la protection et de la sûreté, il comprend la réglementation à respecter pour les pratiques et définit clairement les responsabilités en matière de protection et de sûreté [1].

1.2 Un cadre institutionnel, dénommé « Centre National de Radio Protection » (CNRP).

Relevant du Ministère de la Santé Publique, il est habilité à autoriser et à inspecter les activités mettant en œuvre les rayonnements ionisants, à veiller au respect des lois et règlements et à prendre des mesures coercitives à l'égard des contrevenants.

La loi portant création de cette institution définit de façon précise ses missions et ses attributions, afin d'éviter tout chevauchement d'autorité dans ce domaine [2].

Le CNRP possède des ressources financières et un personnel qualifié pour assurer ces tâches.

La compétence de son personnel a été acquise grâce à la formation qu'il a reçue tant sur le plan national que sur le plan international et régional, dans le cadre de la coopération avec l'Agence Internationale de l'Energie Atomique (AIEA), les projets AFRA, l'Organisation Mondiale de la Santé (OMS) et l'Agence Arabe de l'Energie Atomique.

1.3 Un ensemble de procédures administratives : **« les autorisations »**

Le contrôle mis en place s'appuie sur des procédures d'autorisation, mettant en application les Normes Fondamentales de radioprotection. Sont soumis à autorisation :

- l'acquisition en vue de la commercialisation
- l'acquisition et l'utilisation
- la cession
- le transfert de tout équipement émetteur de rayonnements ionisants et de sources radioactives
- le transport des sources radioactives.

La demande d'autorisation est présentée par le responsable de l'institution où se déroule la pratique et doit comprendre toutes les informations figurant dans le manuel des procédures.

Chaque source fait l'objet d'une autorisation spécifique. Tout changement dans les conditions de son utilisation donne lieu à une révision de l'autorisation. Enfin, l'autorisation est personnelle et ne peut être transmise d'un titulaire à un autre sans l'accord du CNRP.

Dans le cas d'une source radioactive scellée, l'autorisation est octroyée sous réserve du contrôle du colis radioactif contenant la source au passage des frontières tunisiennes. Cette mesure récente permet de vérifier l'indice de transport et de s'assurer que le colis n'a pas subi de dommages lors des opérations de manutention.

1.4 Un ensemble de procédures techniques : **« les contrôles »**

Pour le contrôle des équipements émetteurs de rayonnements ionisants et des sources radioactives et de leur système de protection, ainsi que des locaux dans lesquels ils sont implantés, nous distinguons :

- Les contrôles assurés par le CNRP, et effectués :
  - avant la première mise en service d'un équipement,
  - lors d'une modification des locaux ou des équipements,
  - en cas d'intervention, de dépassement d'équivalent de dose signalé par le service de dosimétrie, d'incident ou d'accident radiologique, et d'une réquisition judiciaire ou du Ministère de Tutelle.

  Ces contrôles sont spécifiques à chaque pratique et à chaque type de source.

- Les contrôles effectués par l'utilisateur même de la source et relatif à son fonctionnement et à sa maintenance.

1.5 Un manuel de procédures administratives et techniques et des guides de bonnes pratiques

Ce manuel, établi par le CNRP, définit les différentes prestations de service en matière de protection radiologique et de sûreté des sources. Il prescrit les conditions à satisfaire et les procédures à suivre pour l'obtention de l'autorisation.

Ce manuel mis à la disposition de l'utilisateur et des agents du CNRP permet l'application du protocole préétabli. Ceci assure l'uniformité de toutes les procédures quel que soit l'agent, ainsi qu'un gain de temps pour l'utilisateur.

1.6 Une base de données

Toute source de rayonnements ionisants autorisée fait l'objet d'un enregistrement.

Ceci permet de connaître :

- le nombre et la nature des sources de rayonnements ionisants,
- leurs différents domaines d'application,
- leur répartition géographique,
- leur évolution dans le temps.

1.7 Un programme de formation périodique et de séminaires d'information portant sur la radioprotection.

Cette formation est destinée au personnel :

- de la douane qui constitue la première « barrière » de protection,
- des ports aériens et maritimes,
- de la protection civile,
- des services médicaux,
- des institutions industrielles et agricoles.

2. Programme de mise a niveau des mecanismes de surete des sources radiologiques

L'infrastructure mise en place depuis 1981, résultat d'une collaboration fructueuse avec l'AIEA et l'OMS, constitue une base de sûreté indispensable. Toutefois, la rapidité du rythme d'évolution au cours des dernières années a fait apparaître certaines insuffisances.

Le nombre d'équipements mettant en œuvre des sources de rayonnements ionisants s'est en effet accru de façon sensible et ce en raison du développement économique, de l'élévation du niveau de vie et des besoins en matière de santé (introduction de techniques nouvelles en diagnostic et en thérapie), de l'intensification de la prospection et de l'exploration de nouvelles sources d'énergie et d'eau, et enfin d'une plus grande rigueur en matière de sécurité des personnes et des biens [3, 4, 5].

Pour une meilleure maîtrise des risques radiques inhérents à cette situation et dans la perspective du démarrage des activités du Centre National des Sciences et Technologies

Nucléaires (CNSTN), le CNRP a élaboré un programme d'action dont les principales composantes sont les suivantes :

- Adopter un certain nombres de textes actuellement en cours d'élaboration, relatifs notamment :
  - aux nouvelles normes de radioprotection [6],
  - au transport des matières radioactives,
  - à la gestion des déchets radioactifs.

  Ces textes sont importants et correspondent à des problèmes pratiques que le CNRP doit résoudre chaque jour. En effet, les sources radioactives « mobiles » utilisées dans le domaine du contrôle non destructif présentent un danger potentiel, et il est donc nécessaire de réglementer leur transport.
- Garantir le respect des prescriptions par des contrôles périodiques qui seront fixés en fonction des risques que présentent les sources.
- Etablir un programme de mise à jour pour le personnel du CNRP.
- Etablir pour les utilisateurs un programme de formation spécifique pour chaque domaine d'utilisation, délimitant les responsabilités, et fixant les règles de comportement général à l'égard de la sûreté et les mesures immédiates à prendre en cas d'incident.
- Réaliser un entreposage des sources scellées usées importées avant la réglementation. Ceci évitera la dispersion des colis des déchets sur l'ensemble du territoire et les incertitudes liées à la pérennité de leurs gestionnaires.
- Etablir un programme de sensibilisation pour les ferrailleurs afin qu'ils puissent prendre les précautions nécessaires en cas de détection d'une source radioactive dans un matériel réformé.
- Etablir un plan d'urgence. L'une des propriétés de la sûreté étant la prévention de l'accident, un logiciel a été élaboré dans ce sens, permettant la simulation d'une perte d'une source.
- Evaluer l'efficacité de notre système.

Pour mettre en application ce programme, il faut disposer :

- de ressources humaines plus importantes ayant un niveau professionnel élevé et compétentes en matière de radioprotection ,
- et de moyens matériels pour la réalisation de ces objectifs.

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THE PREVENTION OF THE LOCAL NUCLEAR ACCIDENTS IN THE REPUBLIC OF MOLDOVA

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Present time in the Republic of Moldova is in storage and in exploitation the sources of ionizing radiation of 134 enterprises, organizations and institutions, on the base of which are situated 374 nuclear facilities (sections, laboratories, departments, divisions). These facilities apply about of 7500 sources of ionizing radiation, more of 60 % are presented by radioisotope devices. The principal fields of nuclear and other source use are medicine, science, education, industry, construction, agriculture, etc.

In the republic are not nuclear reactors, however in radius of 400 km from the borders there are 8 Nuclear Power Stations, and in case of accident the territory of the republic are subject of radioactive pollution.

The more powerful sources (nuclear dangerous) are situated on the territory of the Central Waste Disposal Facility, the Oncology Institute, the Institute of Viticulture, the Academy of Sciences, the Agrarian University, "MoldavIzolit" Factory.

Radioactive sources are presented by the following radionuclides: Thritium-3, Beryllium-7, Carbon-14, Phosphorus-32, Cobalt-60, Strontium-90, Technetium099m, Indium-113m, Iodine-125, Iodine-131, Xenon-133, Caesium-137, Iridium-192, Radium-226, Plutonium-239, and Americium-241. Every year on the territory of the republic are carrying out 2-4 expeditionals nuclear facilities (mainly in the field conditions).

For nuclear and other ionizing radiation sources transportation by the users are used 10 specialized autocars, also the Central Waste Disposal Facility are use 4 specially equipped autocars for transportation of radioactive wastes.

In the republic there are no production of ionizing radiation sources. In the system of exploitation, storage, transportation of the sources and disposing of the radioactive wastes are involved about 1470 employers (professional exposure) the 1347 of who are the medical staff.

Rather exist radiation supervision system was no enough effective in the conditions of insufficiently experience and weak material and technical base. From 1993 The IAEA-cooperation *make the possibility to inherent in the republic the base of national system of Regulatory Control in* the field of Nuclear Protection and Safety. Within the projects of the Republic of Moldova

INT/9/143, RER/9/056, RER/9/008, and RER/9/009 approved by IAEA and the active contribution of the Regional Manager A. Bilbao it was stimulated the National Infrastructure of Radiation Safety and Protection Management. In December 1997, the Law of Radiation Safety and Protection No 1440-XIII was adopted in the Moldova. In accordance with this Law, in the Moldova was established Regulatory Body in the field of Nuclear Safety and Protection from three bodies, as following: the Ministry of Health; the Department of Standardization, Metrology and Technical Supervision "MoldovaStandard"; the Department of Civil Protection and Emergency Situations. All these bodies carrying out state supervision in respective field. Also these bodies carrying out:

- radiation factor standardization;
- sources notification and licensing;
- radiological supervision of sources storage, exploitation, and disposal:
- radiological monitoring of radioactive substances maintenance environmental, food products, building materials;
- staff and population exposure supervision; radiological accidents investigation and organization of liquidation, etc.

In January 1998, the Republic of Moldova has jointed the International Conventions:

1. The Conventions on Early Notification of a Nuclear Accident.
2. The Convention on Nuclear Safety.
3. The Convention on Assistance in the Case of a Nuclear Accident of Radiological Emergency.
4. Vienna Convention on the Physical Protection of Nuclear Material.

Also, in Moldova was elaborated and approved the Temporary Acceptable Levels (VDU-96). The Decision Project "About Organization of the Regulatory Body Activity in the Field of Radiation Safety and Protection"(Project RER/0/015) is prepared for Government consideration. This Project is the mechanism of realization of above-mentioned Law. In present time, the basic situation of this Law is in realization. The following work is continued: national normative acts in field of Radiation Safety and Protection elaboration; International Basic Safety Standards for Protection Against ionizing Radiation and for the Safety of Radiation Sources introduction as the unique normative document in assurance of Radiation Safety and Protection of sources, decreasing of exposure levels to the staff and population.

The sources of ionizing radiation and radioactive wastes notification and registration are carrying out by our elaborated automatized PC-program "ACCIDENT", and from 1998 after extraordinary inventarization of sources we are give as base the "RAIS"-program elaborated by IAEA. The estimation of staff exposure levels involved in work with ionizing radiation is carrying out with also our elaborated PC-program "IDC Workstation".

Table 1.

The local radioactive accidents in the Republic of Moldova from 1960 till 1997

No.	Institution	Year	Source	Victims
1.	Sanatorium, Camenca district	1962	Ra-226	3
2.	Sugar factory, Alexandreni distr.	1978	Cs-137	3
3.	Polyclinic No.1 Chisinau	1981	Roentgen	4
4.	Sugar factory, Falesti district	1986	Cs-137	-
5.	Trust "Cpetstroimehanizatia"	1986	Pu-239+Be-7	-
6.	Experimental Furniture Factory	1988	Pu-239	-
7.	Silk Factory, Bender	1988	Pu-239	-
8.	Living House, Chisinau	1990	Ra-226	1
9.	Custom Leuseni	1993	-	-
10.	Sugar factory Cupcini	1993	Cs-137	-
11.	Factory "COMPEX"	1994	Pu-239	-
12.	Association "Zorile", Chisinau	1994	Pu-239	-
13.	Agriculture Institute Tiraspol	1994	Pu-239+Be-7	-
14.	Supermarket, Chisinau	1996	Pu-239	-
15.	Custom Leuseni	1997	Co-60	-

The National Committee for Radioprotection in co-operation with Regulatory Bodies are identified the priority directions of activity in the field of Radiation Safety and Protection and elaborated the recommendations for introduction. In Moldova is elaborated: the System of Planning and Emergency Respond in the Case of Major Nuclear Accident inclusively with transboundary effect; exchanging of information and coordination of actions with neighbor states. On the radiological dangerous facilities are regenerated the instructions in case of radiological accident, the instruction and training is performed periodically with involved staff.

The work carrying out didn't exclude the possibility of radiological accident appearance. After the data of Ministry of Health in the Moldova from 1960 till 1997 was registered 15 local radiological accidents (Table 1) inclusively:

- 8 on industrial enterprises,
- 2 on medical institutions,
- 2 in custom-house,
- 1 in living house and
- 1 in supermarket.

The total quantity of victims are 11 persons, from which only 2 persons are the involved staff and the rest are the outsiders inclusively 7 adolescents. In case of 8 radiological accidents was no the victims. The 6 persons had the dose more of Annual Limit Dose for staff (50 mSv). The acute local radiation damaging was established on 7 persons, which have the local absorbed dose have the value 4-5 Gy. The hands and whole body radioactive pollution was established in one case. The environmental local radioactive pollution was established in 3 cases, and the radioactive pollution of transport and objects was established in 2 cases. For all victims prognosis was favorable. The victims are on periodical medical supervision. In 7 cases from 15 radiological accidents the source of ionizing radiation was the Plutonium-239, in 3 cases - the Caesium-137, in 2 cases - the Radium-226, in1 case - the Cobalt-60, and in 1 case fluorography installation.

The radioactive accident causes are distributed as follow:

- in 9 causes - loss of sources,
- in 2 causes - misappropriation of sources,
- in 2 causes - personnel irresponsibility,
- in 1 cause - the radioactive polluted autocar use for food products transportation,
- in 1 cause - the attempting to illegal source transportation through custom-house.

In all causes of radiological accidents was carrying out the official investigation, the estimation of possible consequences, the causes elucidation, elaboration of protection and prophylactic measures, the medical examination, the accident consequence minimization, the interested bodies and population information, the guilty persons attraction to the responsibility, the lessons learning. In official investigation carrying out was involved the competent specialists of Regulatory Bodies and also specialists from policy, custom, environmental protection, etc. More effect and help the specialists give the PC-program "ACCIDENT" for measure acceptance and accident investigation. The final Report about radiological accident investigation and liquidation are presented to the institution leaders, and also to the competent bodies.

The prevention of local radiological accidents is one of the principal tasks of regulatory bodies in the field of Radiation Safety and Supervision.

VERIFICATION OF COMPLIANCE, MONITORING OF COMPLIANCE AND ASSESSMENT OF THE EFFECTIVENESS OF NATIONAL PROGRAMMES FOR THE SAFETY OF SOURCES, INCLUDING DEVELOPMENT OF PERFORMANCE INDICATORS

(Technical Session 6)

IAEA-CN-70/49

APPROACH FOR ASSESSING THE EFFECTIVENESS OF REGULATORY CONTROL IN PERU USING PERFORMANCE INDICATORS

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Abstract

The paper is intended to make an approach for assessing the effectiveness of *regulatory activities in Peru by using of performance indicators for each of the activities developed pursuant their responsibilities. So inspections, authorizations, enforcement and regulation activities are qualified by levels of attainments and then assessed independently to rise specific issues. The general conclusion is that regulatory activities seems to be acceptable but some improvements are needed in order to reach a good level of performance.*

1. Introduction

The regulatory functions in Peru, are under responsibility of Instituto Peruano de Energía Nuclear – IPEN, as prescribed by law. The technical and administrative requirements are established on the Radiological Safety Rule [1] this being the top level regulation.

The regulatory activities comprise the issuing of rules and authorizations, performing of inspections and the enforcement.

It has been felt that both the program and staffing have helped to develop all of these regulatory activities in an acceptable manner. However, a verification of effectiveness is always required from time to time in order to make improvements to the current level of control.

The assessment includes the inspection activities, authorizations, enforcement actions and regulations.

2. Setting up the performance indicators

Some performance indicators, taken from reference [2], have been set up for each assessed aspect accordingly the following:

a) Inspection: following actions, assessment of results, solution of findings
b) Authorizations: procedures for granting authorizations, supervision of procedural actions.
c) Enforcement: appropriate and timely actions and the achieving of proposed safety and protection goals.
d) Regulations: sufficiency and clearness of rules.

Qualifications are set for three levels:

- **Favorable:** action has appropriate contributed to fulfill the regulatory function and the required measures help to maintain a good protection and safety level.
- **Fair:** undertaken actions are acceptable but not enough appropriate.
- **Unfavorable:** actions are not sufficient to assure that regulatory functions are fulfilled.

3. Assessment of activities

All of the indicators have been derived from existing data in regulatory records – coming from users under control. These indicators are grouped and then reviewed to make the qualification.

3.1. **Inspections** Rutinary inspections are performed over medical and industrial facilities using radiation sources. Data comes from almost 1500 inspections performed along 5 years. At first, data from inspection results are grouped to show the extent of verifications performed. These indicators are displayed in the Table 1 below.

Table 1. Qualification of indicators derived from inspections

INDICATOR	FAVORABLE	FAIR	UNFAVORABLE
Correct use of devices	50% good	25%	30% poor
Good safety engineering	96% good	3%	1% poor
Following of procedures	60% good	5%	35% poor
Staffing	50% good	30%	20% poor
Staff turnover	48% low	35% medium	17% high
Record retrieval system	10% good	10%	80% poor
House keeping	45% good	23%	32% poor
Financial stability	35% good	48%	17% poor
Average performance	**45,5%**	**27,3%**	**27,2%**

These results are used to define the effectiveness of the inspections through the indicators shown in Table 2. In this particular case, the words Favorable, Fair and Unfavorable match with Action, Only Recording and Non Action respectively.

Table 2. Indicators qualified in the inspection activity

INDICATOR	FAVORABLE	FAIR	UNFAVORABLE
Following actions	10%	80%	10%
Assessment of results	5%	80%	15%
Solution of findings	5%	---	95%
Average performance	**6,67%**	**53,33%**	**40%**

The low average performance is due to that qualification took into account just what directly is result from inspection, but it is necessary to state that the other results are linked with enforcement actions or authorization procedures (e.g. solution of findings are a previous condition for licenses renewal.

3.2. **Authorizations**: Licenses or registers granted to all of the users of radiation sources non exempted. The kind of authorization – license or register – depends on the signification of risk arose by practice. Authorizations are granted linked to specific conditions and limitations and become the framework of protection and safety to the practice granted. The procedure for granting authorizations must be clear and concise in order to determine that the technical requirements are met by the requesting facility. Indicators assessed to determine the effectiveness of the activity are shown in Table 3.

Table 3. Qualified indicators for authorizations activity.

INDICATOR	FAVORABLE	FAIR	UNFAVORABLE
Procedures available for all practices	16%		84%
Procedural actions	60%	35%	5%
Supervision of procedural actions	20%	56%	24%
Average performance	**32%**	**30,33%**	**37,67%**

The average performance trends to an acceptable level, if Favorable and Fair percentages are added up, but the procedures need to be improved.

3.3. **Enforcement**. The regulatory requirements are fulfilled by all of the users of radiation sources however, due to that some users do not fulfill their obligations it is necessary to apply coercive measures, here called enforcement. This activity includes procedures for previous notices and for sanctioning in order to achieve that users accomplish the laws and rules. Four indicators of effectiveness are assessed from data collected in records of the regulatory body. In the table 4 are shown the qualifications of these indicators.

Table 4. Qualified indicators for enforcement activity

INDICATOR	FAVORABLE	FAIR	UNFAVORABLE
On time notification	30%	33%	37%
Control of deadlines	50%	25%	25%
Sanction on time	73%	15%	12%
Following of users responses	25%	22%	53%
Average performance	**44,5%**	**23,75%**	**23,75%**

The average performance is deemed appropriate and a few efforts will be needed to achieve an excellent level.

3.4. **Regulations**. In order to make clear the requirements of regulatory body to users of radiation sources, performance and prescriptive rules are prepared and approved. It is considered that not all of the practices will need prescriptive rules and the general criteria may be enough suitable. The effectiveness of this activity may be assessed taking into account the opinions and needs stated by users of radiation sources, when they found not easy understand what the regulatory body wants. The choosen indicators are related to quantity and suitability of rules existing and to the lack of some others. In the Table 5 are shown these indicators and the qualification for them.

Table 5. Qualified indicators for regulatory activities

INDICATOR	FAVORABLE	FAIR	UNFAVORABLE
Enough prescriptive rules	10%	23%	67%
Suitable criteria to meet requirements	60%	18%	22%
Clearness of rules	37%	26%	37%
Easy to understand requirements	26%	25%	49%
Average performance	**33,25%**	**23%**	**43,75%**

In spite of general performance is appropriate, as this field is linked with authorization activities, it would need to rise the level of performance.

4. Conclusions

In a general view, the performance of regulatory activities seems to be acceptable for fulfilling the commissioned functions. However, the specific results show too that it is necessary to improve the effectiveness of these activities. Some of these identified needs are:

- lack of more prescriptive rules addressed to some practices (X ray diagnostic, nuclear medicine, brachitherapy and radiotherapy).
- improving of authorization procedures, specifically for those practices with high potencial risk, and stressing a more in-depth assessment.
- lack of additional requirements to improve the protection and safety.
- lack of re-assessment of inspection schedules.

It is expected that an improvement in the regulation and authorization activities will cause a general improvement in the whole performance of the regulatory body. This will help to fulfill both national and international [3] safety and radiation requirements.

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LA PROBLEMATIQUE LIEE A LA MANIPULATION DES SOURCES DE RADIUM-226 EN ESPAGNE

XA9848219

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Abstract

Ra-226 started to be used in Spain in the decade of the twenties. During several decades, before the regulatory control was established, a number of users, mainly radiologists practising radiotherapy, gynaecologists and dermatologists, imported a large number of Ra-226 sources into the country. Once the regulatory authority was established, the reconstruction of the source inventory was initiated. With the support of the General Direction of Health, and of commercial enterprises a list of possible owners of Ra-226 was obtained. The list included 175 persons or companies and a total activity of about 20 Ci. A campaign for location of the sources was initiated in the different provinces; the campaign involved contacts with the College of Physicians, as well as Radiological, Radiotherapeutical, Dermatological and Gynaecological Societies. as a result, a total of 3,101 sources with a total activity of 15 Ci were located, retrieved and safely stored; therefore, about 5 Ci remain still to be located; moreover, since the list might only account for about 80% of the actual sources, there is still a significant number of sources missing. In 20 cases leakage of the sources was found, in two of them there was a large contamination requiring significant decontamination actions. The campaign continues up to present; the difficulties in tracing the sources increase with time, due to death of possible Ra-226 owners and relatives.

1. Introduction

Il est bien connu de tous que la découverte des Rayons X par Roentgen en 1895 et de la radioactivité par Becquerel en 1896 ouvrit les portes à un vaste champs de connaissances. En 1934 les époux Joliot-Curie découvrent la radioactivité artificielle, ce qui permit le développement de l'application de ces nouvelles sources d'énergie dans différents domaines, aussi bien dans le diagnostic que dans la thérapie.

Les premiers effets nocifs sur l'homme apparurent dès le début de l'utilisation des radiations ionisantes, c'est pourquoi il s'avera nécessaire de contrôler leur manipulation. De fait, un des effets à long terme, le développement d'une tumeur, put se constater dès 1902, le premier cancer connu, fut celui qui apparut à Gruble en 1896 après de nombreux jours d'exposition, en analysant certains produits avec le tube de Krokes.

En Espagne, ainsi que dans d'autres pays, l'effet curatif produit par la radiation gamma provenant d'un isotope isolé de l'uranium naturel, le Radium-226, fut rapidement reconnu. A partir des années 20, beaucoup de spécialistes en Espagne introduirent la nouvelle technique thérapeutique. Les sources radioactives provenaient soit de "l'Union Minera de Alto Katanga", principal producteur de celles-ci, des producteurs des EEUU, ou directement d'autres usagers d'Europe, jusqu'à la création de la "Junta de Energia Nuclear" en 1951, organisme auquel l'état confia, entre autres tâches, celle de promouvoir le développement de la technologie nucléaire ainsi que le contrôle et la livraison d'isotopes radioactifs. Ce fut le début de l'utilisation des isotopes radioactifs en médecine.

2. Risques des sources de radium-226

Le risque radiologique associé aux sources scellées est celui de l'irradiation externe, mais avec les sources de Ra-226, il existe en plus un risque d'irradiation interne ou de contamination due à la perte d'étanchéité de la capsule.

La pression à l'intérieur de la capsule des sources radioactives augmente de façon ininterrompue, à cause de l'hélium produit par l'émission alpha et à la radiolyse des restes d'eau provenant de l'humidité des processus de fabrication. La probabilité d'apparition de porosités dans les capsules augmente avec le temps, les sources de radium-226 existantes ont plusieurs décennies.

La fuite du Rn-222 est due en premier lieu à la porosité.L'effet thérapeutique est due aux émissions gamma des descendants de période courte du Rn-222, la fuite de gaz implique une perte de l'équilibre radioactif et la dosimétrie physique et clinique du traitement est faussée. En plus, il se produit une contamination de l'air (due au Rn-222) et de la surface (due aux descendants).
Ce qui fait que l'on applique aux patients un traitement erroné, avec le risque supplémentaire d'une possible contamination interne.

Si la mise en capsule de la source présente des fissures ou se détériore due à une manipulation inadéquate, le sel de Radium peut aussi s'échapper. Dans ce cas, les conséquences sont plus graves étant donné sa grande toxicité. La demi-vie du radium-226 (1600 années) prolonge le risque de façon illimitée.

Les sources de Ra-226 se présentent généralement sous forme d'aiguilles et de tubes avec des capsules en platine; certaines vont même dans des gaines en or. Le risque est élevé si un ignorant en la matière possède une de ces sources : en se maintenant proche à celle-ci les doses accumulées localement peuvent être tres élevées et causer des dommages irréversibles.
Des doses jusqu'à 12 mSv/h au contact de la gaine ont été mesurées.

3. Demarches de l'administration

La première réglementation au sujet de la securité nucléaire et la protection radiologique en Espagne est apparué en 1964, lors de la publication de la loi 25/1964 sur l'Energie Nucléaire, ce qui explique que la possession et l'utilisation des sources de radium-226 n'étaient pas réglemetíes, même si c'était la "JUNTA DE ENERGIA NUCLEAR" l'organisme qui accordait les autorisations. Dans la période de 1957 à 1967, cet Organisme a accordé 600 permis d'usage d'isotopes, dont près du 20% étaient destinés à des usages médicaux, et parmi ceux-ci seulement quelques uns pour l'utilisation de sources de Radium-226.

En 1972, le Règlement pour les Installations Nucléaires et Radioactives fut publié. Ce Règlement, dans la disposition transitoire seconde, mentionne : qu´un délai d'un an est accordé pour que les installations nucléaires et radioactives qui se trouvaient en fonctionnement lors de la publication du présent Règlement, remplissent les conditions décrites. De cette façon, l'on prétendait régulariser de fait tous les usagers de sources radioactives "inconnus" par l'Administration de l'Etat.

De tous les possesseurs de Radium-226, très peu furent ceux qui, profitant de la disposition mentionnée, sollicitèrent leur légalisation. Une fois écoulé un délai raisonnable depuis la publication du Règlement sur les installations nucléaires et Radioactives, la "Junta de Energia Nuclear" élabora une liste des potentiels usagers de Radium-226 basée sur ses propres données et celles communiquées par la Direction Générale de la Santé Publique et de Santé Vétérinaire ainsi que par des entreprises commerciales. Dans cette liste figurent 175 personnes ou firmes, parmi celles-ci 156 sans autorisation, avec une activité d'environ 20 Ci.

Une fois établie la liste des probables possesseurs de Radium-226, la "Junta de Energia Nuclear" envoya une carte de dénonciation - pour chaque usager - à la direction Générale de l'Energie, pour que, à travers ses organes opératifs, soient prises les mesures opportunes. La Direction Générale de l'Energie envoya à chaque usager une proposition alternative: ils devaient demander soit les autorisations réglementaires soit le retrait des sources comme résidu radioactif. Malgre la bonne volonté de l'Administration, l'effet attendu ne Fut pas obtenu. La première option fut acceptée par quelques-uns; quant à la seconde, elle fut à peine tenue en compte.

En se basant sur les demandes reçues à la "Junta de Energia Nuclear", des inspections pour contrôler l'état des sources de Ra-226 se déroulèrent dévoilant les faits suivants :

3.1 Systèmes de confinement

Les systèmes utilisés pour le confinement des sources étaient des plus variés , on a utilisé aussi bien les récipients où l'on faisait bouillir les seringues, que des petits coffrets à bijoux, gardés prioritairement dans les chambres à coucher, que des récipients en plomb d'épaisseur variable, allant jusqu'à utiliser, dans les meilleures conditions, des coffres-forts incrustés dans les parois de chambres ou de dépendances, bien gardés, avec les sources gardées à l'intérieur d'alvéoles en plomb.

3.2 Systèmes d'implantation et d'hospitalisation

On ne disposait pas, en particulier, de systèmes spéciaux destinés à l'implantation des sources pour garantir une protection adéquate, cette opération se réalisait dans les locaux habituels. Une fois que l'implantation avait lieu, les patients se déplaçaient à leur destination á travers les couloirs, les ascenseurs, etc... fréquentés par des personnes qui ne devraient pas se faire irradier.

Certains hopitaux disposaient de chambres spécialement prévues pour loger les patients, mais dans la plupart des cas les patients étaient renvoyés chez eux avec les sources implantées, ou bien restaient hospitalisés sans aucune mesure de protection radiologique, allant même jusqu'à l'hospitalisation dans des hôtels.

Personnel

Le personnel facultatif qui réalisait les implantations méconnaissait, en général, les risques que comportait la radiation ionisante, connaissant seulement ses effets curatifs. Quant aux personnes qui soignaient les patients, elles agissaient ignorant totalement les moindres normes de sécurité de protection face aux radiations.

Seulement dans les cas où l'instalation était déclarée comme instalátion radioactive, le personnel était contrôlé radiologiquement, ce qui se produisait dans très peu de cas.

3.4 Contrôle de l'étanchéité des sources

La plupart des sources radioactives n'ont jamais été soumises à des contrôles d'étanchéité depuis leur acquisition, à part ceux qui étaient realisés à l'origine, soit parl'Institut de Radium de Paris soit par "l'Union Minera de Alto Katanga". Dans les quelques cas où l'on a effectué des test d 'étanchéité par des organismes spécialisés, une contamination superficielle des sources a été détectée, sans connaître avec exactitude si celle-ci était due au Radon-222 ou au propre Radium-226.

Vu les résultats obtenus, il fut conclu que le mieux était de tenter de dissuader les possesseurs de sources de Radium de les remettre à la "Junta de Energia Nuclear", pour que dans ses locaux et avec les moyens adéquats, elles soient traitées comme résidus radioactifs.

Le principal problème a été de convaincre les propriétaires de renoncer à un "patrimoine" acquis il y a longtemps déjà et auquel est lié un bien être social-économique, ainsi que de convaincre les usagers qu'il existait d'autres types de sources moins dangereuses. De plus la "Junta de Energia Nuclear" se trouvait face à un problème supplémentaire puisqu'elle devait faire payer une somme considérable en raison de la prise en charge des sources radioactives (transport jusqu'à l'installation par du personnel spécialisé, matériel et équipement adequat, véhicule apropoié, traitement des sources et stockage à vie de celles-ci). Ceci pouvait déclenches une panique économique parmi les possesseurs de sources de Ra-226 qui pourraient opter par une voie plus rapide et les faire disparaître.

En 1980, se créa par loi le "Consejo de Seguridad Nuclear" (CSN) qui assuma toutes les fonctions techniques et de contrôle qui avant correspondaient à la "Junta de Energia Nuclear", le CSN devait aborder le problème de Radium initié préalablement.

En 1981, un accord s'établit entre la Direction Générale de l'Energie et la "Junta de Energia Nuclear" de façon à ce que les sources de Ra-226 soient confisquées par l'Administration sans faire payer des frais à l'usager. Les premiers résultats ne se firent pas attendre, le premier retrait eutlieu en Octobre 1980.

Une campagne d'inspections fut effectuée de façon aléatoire dans différentes provinces, dévoilant l'existence de possesseurs de Ra-226 qui ne figuraient pas dans la liste élaborée, ainsi que la disparition de sources par différentes circonstances (décès du propriétaire, vente ou location des sources). Ainsi il s'avéra prioritaire d'aborder ce qui suit:

Contrôler l'existence des sources qui figuraient dans la liste et essayer de connaître de façon plus précise l'existence d'autres. Accélerer le processus de retrait pour avoir le contrôle physique sur le matériel radioactif.

Jusqu'à la fin 1985, 44 retraits ont eu lieu, dans 12 cas on a trouvé une perte d'étanchéité, parmi lesquelles, 3 étaient dues au propre Ra-226. Il faut mentionner 2 cas de contamination importante connus, produites dans deux hôpitaux de Madrid et Barcelone, qui ont touché aussi bien le mobilier que les locaux et les terrains.

En Décembre de cette année et selon ce qui est indiqué par la Commission Internationale de Protection Radiologique, dans sa publication n° 33, paragraphe 181 :"Le Radium et ses descendants impliquent certainement le plus grand risque potentiel de toutes les sources scellées que l'on utilise en médecine, c'est pourquoi il est fortement recommandé de les stocker de façon adéquate et de les remplacer, aussi tôt que possible, par d'autres radionucléides". Le CSN envoya au Ministère d'Industrie et de l'Energie un écrit proposant la fermeture des installations illégales, en visitant les possésseurs supposés ou leur familles, pour ainsi localiser les sources et faire un inventaire fiable de celles-ci, en prenant les mesures nécessaires de façon à ce que le materiel radioactif ne s'utilise pas et qu'il soit stocké dans des conditions adéquates, ainsi que de fournir un délai de trois mois aux possesseurs de Ra-226 pour qu'ils fassent les démarches administratives afin de demander l'autorisation de l'installation ou le retrait du matériel comme résidu radioactif.

D'autre part, face à l'incertitude sur les sources existentes, le CSN initia une campagne ayant pour but l'accès aux propriétaires inconnus, en prenant contact avec l'Illustre Collège de Médecins et la Société Espagnole de Protection Radiologique, en publiant des communiqués dans les revues spécialisées et dans les congrès de Radiologues et Radiothérapeutes, Dermatologues et Gynécologues, afin de recueillir toute l'information possible nécessaire pour localiser la totalité du matériel radioactif.

4. Situation actuelle

Comme résultat de ce qui précède, il a été localisé et retiré, jusqu'à nos jours, 3101 sources de Ra-226, avec une activité totale de 15 Ci.

D'après des calculs approximatifs, 5 Ci devraient encore être localisés. La liste initialement confectionnée de possesseurs potentiels a une fiabilité de 80%, ce qui voudrait dire que la quantité hors contrôle pourrait être supérieure.

Plusieurs cas de pertes de sources radioactives ont été signalés par les propriétaires. Dans beaucoup d'autres cas, il n'a pas été possible de confirmer que la quantité retirée coincidait avec celle acquise. Dans ce sens il a été fait un grand effort pour, non seulement localiser les sources, mais aussi leur certificats d'origine.

Plus de 20 cas de contamination ont été confirmés, deux d'entre eux de grande envergure comme il a été signalé préalablement.

Le "Consejo de Seguridad Nuclear" essaie, par tous les moyens, de réunir de l'information, en particulier en réalisant des inspections chez les propriétaires potentiels ou la famille de ceux-ci. Les localisations et les retraits de sources ont lieu avec une fréquence qui va en diminuant. Le temps qui s'est écoulé fait que l'information sur les possibles acquisitions se perd progressivement, due au décès des propriétaires.

5. Conclusions

Les sources de Radium-226, à usage médical, introduites en Espagne , sans aucun contrôle, dans les premières décennies de ce siècle, constituent un risque radiologique élevé pour la population, c'est pourquoi leur localisation est une tache prioritaire pour le "Consejo de Seguridad Nuclear".

Les actions de l'Administration ont donné de bons résultats et continuent encore de nos jours. Cependant il reste très improbable de contrôler un jour la totalité de sources qui existent; ceci est dû au manque d'un inventaire complet sur lequel se baser, au temps écoulé depuis leur acquisition, au changement de propriétaire que certaines ont subi, ainsi qu'à leur dispersion à travers le pays et le manque de contrôle sur leur manipulation.

IAEA-CN-70/107

FREQUENCY OF REGULATORY INSPECTIONS

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ABSTRACT

The efficacy of a regulatory system to control radiation sources is determined by its appropriated implementation considering the resources available. The available resources are usually limited and, therefore, the effectiveness of the system can be considered as a problem of optimum assignment of resources.

The frequency of inspections could be established considering a “safety indicator” for different practices, as well as from each registrant records. In this work, how to determine the frequency of inspections to registrants controlled by a Regulatory Authority is analysed. The methodology presented includes use of Decision Analysis techniques and experts' opinion.

1. SAFETY DEGREE OF THE PRACTICE

To authorise a practice, the Authority imposes requirements, through legislation and pertinent regulations. Naturally, they are the least according to the Authority necessary to carry on safely the practice.

We have defined "safety indicator" as a multiatribute quantity related with the nature of practices. Different practices have different values of the safety indicator, which could be used to establish inspection frequencies to verify compliance with requirements.

To assess the value of the safety indicator, each practice characteristics should be considered. Besides safety systems, protection measures, probability, and consequences of potential exposures should also be taken into account. In particular the following items should be considered:

- Requirements imposed to authorise the practice.
- Level of standardisation of the practice.
- Complexity of the practice.
- Risk of internal contamination or external irradiation.
- Typical radioactive inventory.
- Probability and consequences of the potential exposures.

2. THE SAFETY INDICATOR FOR REGISTRANTS BEHAVIOUR

One of the main tools to evaluate the safety indicator of each registrant is the regulatory inspection. Inspections should be planned to obtain the required information; in particular "performance indicators" should be considered. Radiation protection aspects are considered as appropriated performance indicators, for instance:

- Level of compliance with regulations.
- Radioactive inventory.
- Training and retraining level of the personnel.
- Safety systems implemented.
- Doses distribution.
- Monitoring data from inspections.
- Accidents occurred.

3. EVALUATION OF SAFETY INDICATOR

The safety indicator of a practice and for a registrant in particular can be evaluated by means of appropriate Decision Analysis techniques, using experts' opinion [1], [2].
The multi-attribute utility analysis uses a scoring scheme or multi-attribute utility function, U, to rank the practices or installations, considering the l relevant radiological factors. This classification is carried out through utility function for each factor, u_l that indicates the relative desirability of the possible outcome for the factor l. Usually the value one is adopted for the best outcome and the value of zero for the worst one. The multi-attribute utility function is given by:

$$U = \sum_l k_l \cdot u_l$$

where k_l represents scale constants that express the relative importance assigned to each attribute. These constants are generally normalized in such a form that $\sum_l k_l = 1$.

4. THE FREQUENCY OF INSPECTION FOR PRACTICES

Experts' opinion can be used to carry out a formal Decision Analysis or, in a simpler manner, it can be used to rank the practices according to the value of its safety indicator. For example, the following categories could be used:

PRACTICES SAFETY INDICATOR	EXTREMELY LOW	UNACCEPTABLE
	VERY LOW	ACCEPTABLE
	LOW	
	MIDDLE	
	HIGH	
	VERY HIGH	

With practices ranked in categories, according to the safety indicator, a relative inspection frequency can be estimated. Let us suppose that the categories have been selected in such way that it is assigned an inspection frequency equal to zero to practices of higher value of the safety indicator, while to that of smaller acceptable value of the safety indicator it corresponds an inspection frequency of one.
In these circumstances, the inspection frequency can be interpreted as a utility function that represents a scaling of the subjective values assigned by the decision-maker (DM) to the consequences of a decision. The utility function captures the attitude toward risk of the

decision-maker and it reflects his willingness to take chances. These attitudes can express risk neutrality, risk aversion or risk proneness. See Figure 1.

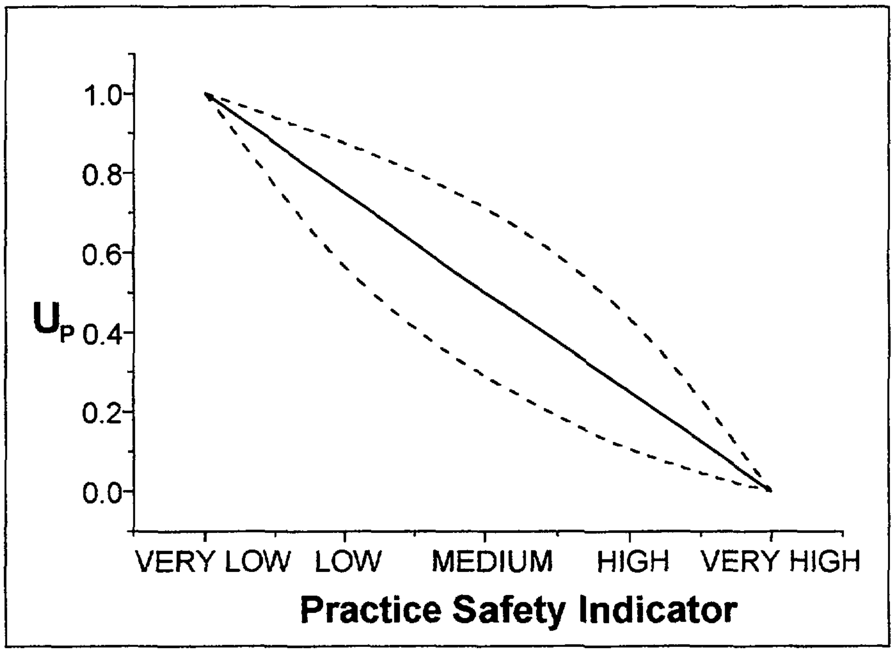

FIGURE 1. Possible shapes of the utility function for the Practice Safety Indicator

There are several techniques to construct the utility function of the DM [3], [4].
If it is established the maximum inspection frequency for the practices of smallest acceptable value of the safety indicator, *M*, and the minimum inspection frequency for the practices with the highest value of the safety indicator, *m*, the inspection frequency for each practice can be determined with the utility function. For the practice *i*, the basic frequency of inspection is given by:

$$BF_i = U_{P_i}(M - m) + m$$

The inspection frequency is called by us "basic inspection frequency by practice".

5. THE FREQUENCY OF INSPECTION EACH REGISTRANT

The analysis of the records on radiological safety of each registrant carrying out a practice allows the deduction of the value of its safety indicator. In this paper, the safety indicator of each registrant is used as a modifier of the basic inspection frequency for the practice.
In order to determine how much the basic inspection frequency should be modified, due to the radiological safety record of each installation, the Decision Analysis technique previously presented can be used. In that sense, the registrants can be ranked taking into account their own safety indicator, in similar way to the categorisation carried out for the practices.
Assuming that the modifier of the basic inspection frequency varies between 0 and 1 and choosing an arbitrary value of 0.5 for registrants with a safety indicator considered normal, the utility function can take the forms schematised in Figure 2

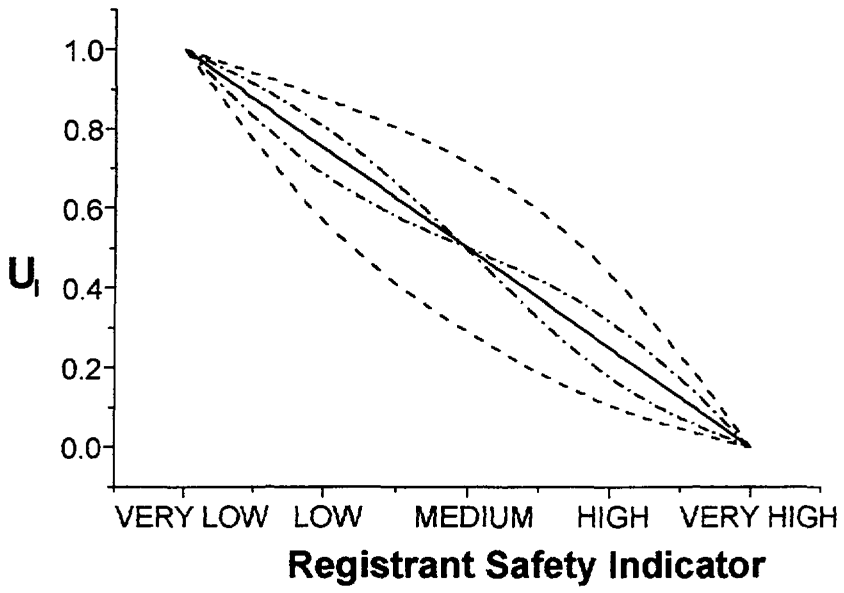

FIGURE 2. Possible shapes of the utility function for the Registrant Safety Indicator

In that sense, the inspection frequency for a registrant *j* that carries out the practice *i* is:

$$F_{ij} = BF_i + k\,(U_{Ij} - 0.5)$$

Being for a new installation $U_{Ij}=0.5$.
The constant k indicates the relative weight that is assigned at the safety indicator of the practice and the safety indicator of the registrant, and can be determined considering the preferences of the DM [3].
In a less rigorous but much simpler way, the constant k can be determined considering how much it could be accepted that the basic inspection frequency per practice is modify by the registrant records.

6. CONCLUSIONS

The proposed method allows determining the inspection frequency to different registrants, considering the value of a safety indicator of the practice, and the records of each registrant. In such way, it is possible to achieve a simple, logical and systematic assignment to the available resources in a complex framework.

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MEASURES TO PREVENT BREACHES IN THE SECURITY OF RADIOACTIVE MATERIALS (FROM PRODUCTION TO DISPOSAL), EXPERIENCE WITH CRIMINAL ACTS INVOLVING RADIOACTIVE MATERIALS

(Technical Session 7)

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MEASURES TO PREVENT BREACHES IN THE SECURITY OF RADIOACTIVE MATERIALS

XA9848221

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Abstract

The objective of this paper, which is the result of the co-operation between ***the Swedish Board of Customs, the Swedish Radiation Protection Institute, The Security Police*** *and* ***the Swedish Nuclear Power Inspectorate,*** *is to give an idea of the national prevention system as to illicit trafficking of nuclear materials and other radioactive sources.*

1. Definitions

When using the term "nuclear materials" in this text we refer to products and materials that are used to produce nuclear power energy.
Other "radioactive sources" do not include fissile materials used in the production of nuclear power energy but comprise all other radioactive material including contaminated scrap material and radioactive waste.

2. The national prevention system

The Swedish opinion is that the fundamental pillars of an international or national prevention system against illicit trafficking of nuclear material and other radioactive sources are proper safeguards, physical protection, export and import control and traditional anti-trafficking measures, all of which must be adequately covered by the legal system of the state. These four regimes interact and provide information to the overall system. Furthermore measures and actions by the involved competent parties should as far as possible be coordinated.

At a national level the efforts to prevent illicit trafficking is coordinated by a reference group consisting of representatives from the different autorities and agencies involved. This group consists inter alia of

- The Swedish Board of Customs
- The Swedish Radiation Protection Institute
- The Swedish Nuclear Power Inspectorate
- The Security Police
- The Defense Research Institute
- The Swedish Coastguard
- The National Inspectorate of Strategic Products

3. Administrations involved

3.1 The board of customs

The duties of the Swedish Customs are laid down in the Swedish Customs Ordinance. One of the overarching objectives for customs activities is

- to supervise and control the trade of goods to and from other countries, so that the provisions on imports and exports of commodities are complied with.

Nuclear material is part of what is classified as dual-use goods. These goods are of course subject to a licensing procedure and the licensing authority is the Ministry of Environment or the Swedish Nuclear Inspectorate.

According to the Swedish regulations the customs authority must be advised **one week in advance** about when the goods are to be exported. As to dual-use goods (including nuclear material) the license and accompanying documents, if any, must be presented to the customs authority in connection with the customs clearance procedure.

The border crossing activities are, with some limitations, controlled by Customs, partly on a routine basis, but of course also as a result of received information regarding suspected illicit traffic activities. As to nuclear materials Customs are not only entitled to control a shipment entering or leaving the European Union but it is also our responsibility to control goods being shipped from Sweden to other Member States. Normally a control of the documents combined with a limited control of the goods is conducted.

3.2 The swedish radiation protection institute

The Swedish Radiation Prtotection Institute (SSI) is a governmental authority with the task to protect people and the environment from the harmful effects of radiation. The SSI ensures that the risks and benifits inherent to radiation and its use are compared and evaluated. The legal basis is the Radiation Protection Act, which requires licences for the manufacture, import, transport, sale, transfer, leasing, acquisation, possesion or use of radioactive substances. The main task of the SSI is to issue directives, perform inspections, give information, advice and education, perform research and administer external research projects. The SSI participates through different organisations, such as ICRP, IAEA, OECD-NEA and UNSCEAR in the field of radioation protection.The SSi is also responsible for co-ordnitation activities in Sweden should an accident involving radiative material occur.

3.3 The swedish nuclear power inspectorate (SKI)

SKI is the regulatory and supervisory body for nuclear activities. In the field of illicit trafficking the responsibility covers:

- safeguards of nuclear material,
- physical protection of nuclear facilities, including storages of nuclear material,
- physical protection of transports of nuclear material,
- export licensing of nuclear material and equipment especially designed and prepared for nuclear use.

The legal basis for the work of SKI is the Act on Nuclear Activities and the EU regulation (EC 3381/94) on export control of dual use goods.

The full responsibility to maintain systems for safeguards and to take appropriate physical protection measures rests with the licensee. The role of SKI is to make sure that the level of security is acceptable. For this purpose inspections at nuclear facilities are carried out on a routine basis and, if needed, an ad hoc basis. Furthermore SKI is the national point of contact for matters concerning the IAEA Illicit Trafficking Database.

3.4 The security police

The main task of the Security Police is to prevent and detect subversive activities that may threaten the national security. The most important measures are those of a preventive character. In order to prevent and detect subversive activities the Security Police has to collect intelligence on circumstances, which may be of importance to both the internal and the external national security. Intelligence is also of vital importance in the combat of terrorism. These tasks, carried out by the Security Police, are normally referred to as "the security intelligence service".

The Security Police has been involved in the combat of preventing profileration of weapons of mass destruction since 1992, the year when the Reference Group also was founded (See paragraph 2). The Reference Group meets at least twice a year with the Security Police as co-ordinating administration. The secretariat of the Security Police also convenes the meetings of the reference group.

4. Measures taken when radioactive material is seized

Should radioactive material be seized, the customs authority closes the area around the seized material whereafter it immediately contacts the radiation protection officer on duty

(TSI) at the Swedish Radiation Protection Institute (SSI). Depending on the situation and the type of material, in situ non-destructive gamma measurement could be performed by staff from the Swedish Radiation Protection Institute or radiation protection staff from a nearby nuclear installation, in order to make a preliminary identification of the emitting radio nuclides.

In this connection it could be mentioned that most of the Swedish border crossing points have a radiation monitoring equipment that could give an indication whether a suspected shipment may contain radioactive material or not. With the assistance of the Studsvik Research Center the radioactive material will then be transported to an authorised storage in Studsvik. The Studsvik Research Center has the necessary competence to analyze the material. An investigation will be started up by the responsible customs authority.

5. Account of the development in sweden

5.1 General

Since the early nineties there has been a downward tendency as to illicit trafficking of radioactive material and other radioactive sources.. It is true that some seizures have been made in our immediate vicinity, but on the whole the illicit trafficking in the aforementioned materials and substances has decreased to a minimum level. Furthermore we have observed a declining interest in such materials and substances among the so called "business men", who were previously engaged in attempts to mediate in the trade of i.a. valuable earth metals and radioactive substances. This development has no doubt contributed to the downward tendency in illicit trafficking.

A former prevailing false notion among those business men was that there was a great deal of money to be made, if only it was possible to find a buyer of the material offered on the market.

Today this "over-confidence" has almost disappeared. One reason is most likely the "awareness programme" that was carried out by the Small Reference Group and particularly as a result of the common efforts made by the Swedish Board of Customs, the Security Police and the National Inspectorate of Strategic Products.

Below, please, find a presentation of the statistics from 1992 to 1997 on reported offers of radioactive material and other radioactive sources as well as seizures of such materials, which have been made as a result of the collaboration between the Swedish Board of Customs and the Security Police.

5.2. Table: Statistics on offers and seizures

Known cases	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Offers of nuclear material and other radio-active sources	5	11	13	5	2	3
Seizures of nuclear material and other radio-active sources	1	1	1	0	0	0
Seizures of weapongrade nuclear material	0	0	0	0	0	0

6. Exchange of information

As to the possibilities of the Swedish Customs to exchange information regarding seized nuclear materials, this exchange is made within the framework of the Council Regulation 1468/81 of May 19, 1981, as well as the bi- and multilateral agreements of administrative assistance in customs matters that the Swedish Government has signed with a number of countries.

The Customs authorities shall, upon request, supply to each other all information which may help to ensure accuracy in the implementation of import and export prohibitions and restrictions, such as the restrictions concerning import and export of nuclear materials and other radioactive sources.

Information regarding seizures of nuclear material and other radioactive sources, such as

- type of substance,
- name of the substances,
- detection,
- details of offenders,
- source of information,
- consignor and consignee

is also sent to the World Customs Organization where it is available to the Member States via the Customs Information System (CIS).

Information of seizures of nuclear material and other radioactive sources is reported to the IAEA-Illicit Trafficking Database by the the Swedish Nuclear Power Inspectorate.

7. Conclusion

The Swedish method to combat the illicit trafficking of nuclear material and other radioactive sources through a close co-operation between the different administrations involved has proved to be successful and it is our firm conviction that future increased efforts and closer co-operation will make the Swedish combat even more efficiant.

PHYSICAL PROTECTION OF RADIOACTIVE MATERIALS IN A UNIVERSITY RESEARCH INSTITUTE

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ABSTRACT

Although nuclear research centers attached to universities usually do not keep large inventories of radioactive or special nuclear material, the mentioned material has still to be under strict surveillance and safeguards if applicable. One problem in such research centers is the large and frequent fluctuation of persons - mainly students, scientists or visiting guest scientists - using such materials for basic or applied research.
In the present paper an overview of protective actions in such a research institute will be given and experience of more than 36 years will be presented.

1. INTRODUCTION

The Atominstitute of the Austrian Universities is an interuniversity institute founded in 1959 and officially inaugurated in March 1962. Its main research facility is a 250 kW TRIGA Mark-II reactor with pulsing capability up to 250 MW. The institute is devoted to the education of students in the Master and PhD level in fields such as

- neutron and solid state physics
- nuclear technology
- radiation protection and dosimetry
- radiochemistry
- low temperature physics
- x-ray physics.

About 35 professional staff and 30 technicians train about 50 students per year in the above fields. In addition, more than 100 specialized lectures and 10 practical courses are offered during the educational program.

In addition, due to the fact of the proximity of the IAEA many fellows and visiting guest scientists are hosted at the institute and training courses are carried out in cooperation with the IAEA.

In view of the educational program the institute not only stores more than 90 TRIGA fuel elements, most of them in the reactor core, some of them in a fuel storage facility, but also small samples of Special Nuclear Material (SNM) and other radioactive sources for calibration and standardization of instruments. A part of these sources do not even belong to the institute but is stored for and under contract with the IAEA to be used as calibration sources for IAEA-safeguard instruments (Table 1).

Table 1: Special nuclear material and radioactive sources stored at the Atominstitut (approx. values only)

1. Radioactive Sources (activity as of December 1997)

Co-60	1	2.12	MBq
Co-60	2	114	MBq
Co-60	3	437	MBq
Co-60	4	34.7	MBq
Co-60	5	7.6	MBq
Co-60	6	8.7	MBq
Co-60	7	0.9	MBq
Cs-137	1	101	MBq
Cs-137	2	673	MBq
Am-241	1	3700	MBq
Pu-239	1	377	Bq
Sr-90/Y-90		740	kBq
Tl-204		185	kBq
Am-Be		111	GBq
Pu-Be		111	GBq
Pu-Be		11.1	GBq

2. Special Nuclear Material

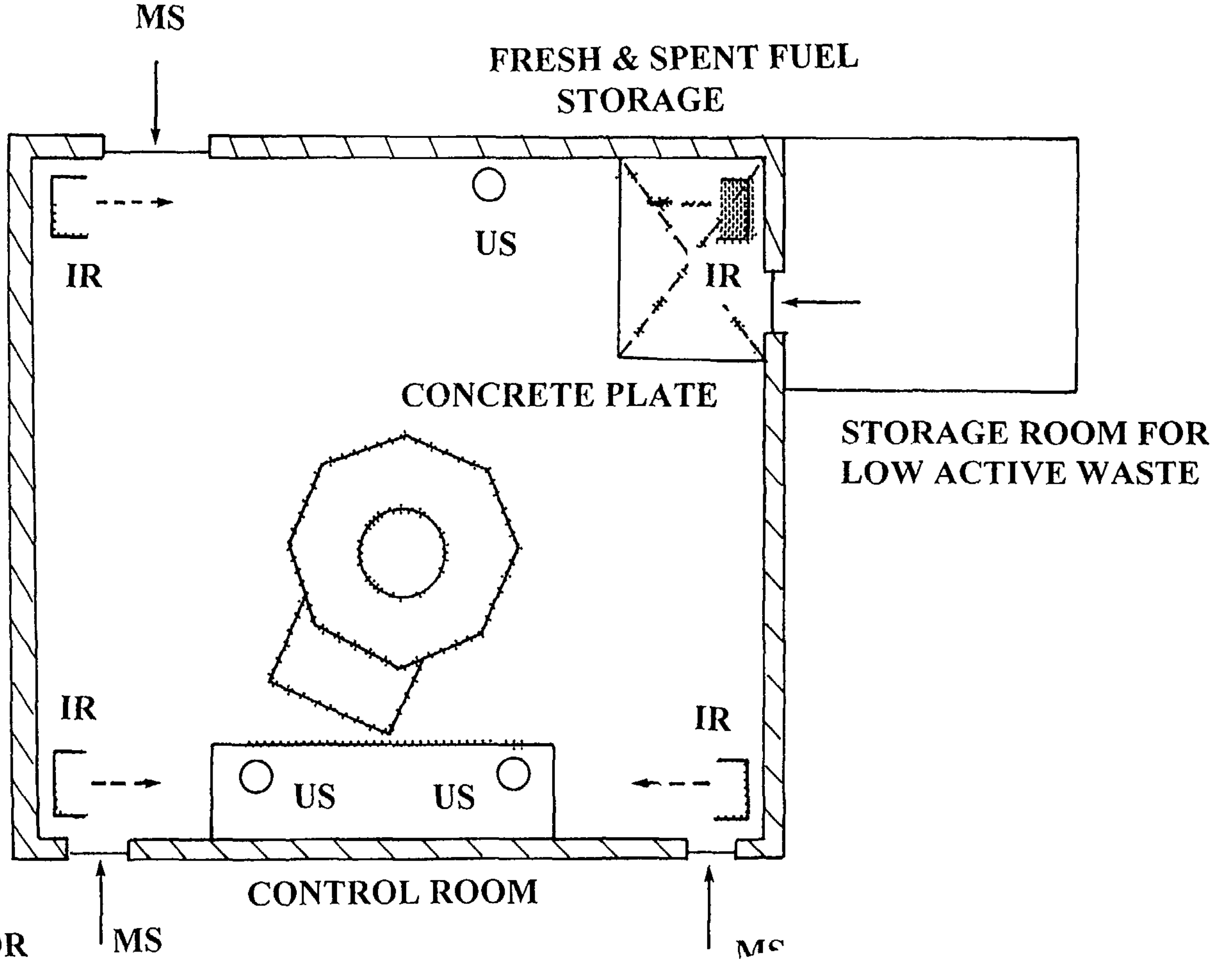
HEU	total	~ 1 900 g
HEU	U-235	~ 1 300 g
LEU	total	~ 155 000 g
LEU	U-235	~ 6 700 g
Depl. U		~ 23 kg
Pu		~ 60 g

2. PHYSICAL PROTECTION

According to the National Law for Radiation Protection radioactive material and Special Nuclear Material must be protected accordingly, unauthorized access must be prohibited and special security measurements must be enforced.

The first barrier is a round-the-clock entrance guard at the institute's main entrance. The public area of the institute with auditorium, library, director's office etc. are physically separated from the laboratory areas by locked doors and only staff members and enrolled students are entitled to access these rooms.

The reactor hall is again separated by self-closing doors from the laboratory area with another type of access key which is only issued to students actively working at the reactor facility. The keys both for the laboratories and the reactor hall are individually numbered and registered at the reactor management (Figure 1).



MS - DOOR MICROSWITCH
US - ULTRASONIC DETECTOR
IR - INFRARED DETECTOR

SCHEME OF PHYSICAL PROTECTION INSTALLATION AT
THE TRIGA MARK II REACTOR VIENNA

Entitled students are allowed into the reactor hall at weekdays between 7 a.m. and 9 p.m. Outside this period an automatic surveillance system consisting of a combination of key-lock microswitches, ultrasonic and infrared detectors is activated with a direct connection to the nearest police station. Any unauthorized access will trigger an immediate alarm.
The alarm panel is mounted in the entrance guard room staffed round the clock.

Inside the reactor hall there are four main areas to be specially protected, all of them contain Special Nuclear Material or radioactive sources.

a) The reactor with the fuel elements,
b) the fresh and spent fuel storage facility,
c) the safe containing various samples of Special Nuclear Material to be used for experiments, and
d) the reactor storage room containing several neutron sources.

All four areas are additionally controlled by remote sensors which are connected to the central alarm system. The storing places for the above mentioned materials and sources are internally controlled by the reactor staff every month, and externally controlled by EURATOM and IAEA.

The main entrance of the institute is controlled by a very sensitive fast-response scintillation detector to prevent any unintentional transport of radioactive materials outside of the institute. It triggers an alarm when the normal background level is exceeded by 100%, and it is connected to a data logging system.

3. SAFEGUARDS

Austria as an NPT country and a member country of the European Community is subjected to the EURATOM control system for Special Nuclear Material. Therefore, the facility has to report any inventory change (ICR), carry out an annual physical inventory listing (PIL), and report annually the material balance (MBR). This has been done up to 1998 by filling out the appropriate lists and transfer them to EURATOM through the official national channels which is the Federal Chancellery in Austria. Since 1998 all data are now in a computerized form and transferred through e-mail parallel to EURATOM and to the Federal Chancellery. This increases information speed and reduces possible data entry errors.

4. PRACTICAL EXPERIENCE WITH SAFETY AND SECURITY OF RADIO-ACTIVE MATERIAL

The Atominstitut has been officially inaugurated in March 1962 and has accumulated, therefore, more than 36 years of practical experience with radioactive sources and Special Nuclear Materials. The safeguard program became really operational in the early seventies while the complete security surveillance system started its operation in the early eighties. Before these dates the sources and SNM were controlled by good housekeeping and according to the standards under application at these times.

The security measures installed in the eighties consisted of multiple barrier access doors, visitors' badges, door and room surveillance systems and exit control. As there is a large in- and outflow of students attending lectures and courses at the Atominstitut, the institute is separated into a non-controlled area (auditorium, seminar room, library) and into a controlled area where the laboratories and the reactor are located.

During the past 36 years we only had one case where a student tried to take out a low activated gold foil used for flux mapping. This was immediately detected by the sensitive Na(J) scintillator at the entrance guard and appropriate measures were taken. The gold foil was appearantly diverted during a practical course where the students had to perform neutron flux mapping at the TRIGA reactor.

No other incidents were observed and the entrance/exit control station is usually triggered when small radioactive samples are delivered to or shipped from the institute.

5. SUMMARY AND CONCLUSION

University institutes are usually low budget, easy going facilities where strict industrial rules cannot be applied. Therefore, a compromise has to be established between appropriate security measurements and open access to academic facilities. Strict security measures would ultimately reflect the students away from all possibilities offered by a university institute for academic education. The Atominstitut has demonstrated in the past 36 years that such a compromise is possible and the number of graduate students (more than 1000) from our facility is the best reference that this compromise had been a success.

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STRENGTHENING THE SECURITY OF RADIATION SOURCES IN GHANA

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Abstract

Legislative instrument LI 1559 of 1993 established the Radiation Protection Board (RPB) as the National Competent Authority (NCA) on radiation matters in Ghana. The Board advises Government through the Ghana Atomic Energy Commission on matters relating to radiation safety, security of sources, sales, import and export, contamination in food and environment, among others. It has wide ranging regulatory powers and works in association with country authorities. The regulations in place for controlling the movement and use of radioactive materials in Ghana are discussed. Accountability for radioactive materials especially for those which were brought in before the establishment of the RPB have been the focus of our discussion. The need to for intensify educational programs for the public on matters relating to effects of radiation on man and environment is recommended. Strengthening of regulatory control of sources and intensifying efforts against smuggling, unauthorised use and systems for notification on radioactive transport accidents are noted.

1. Introduction

The Ghana Atomic Energy Commission (GAEC) was established by an act of parliament (i.e. Act 204 of 1963, [1]) to be responsible for all matters relating to the peaceful uses of atomic energy and to advice Government on such matters. This act was amended by the Provisional National Defence Council (PNDC) Law 308 with the establishment in January 1993 of the Radiation Protection Board (RPB) under legislative instrument LI 1559 [2]. Until then, there was no legal framework enforcing the registration, licensing and safe handling of radiation sources. However the use of ionising radiation in Ghana dates back to the early nineteen fifties and therefore many sources and equipment for generating ionising radiation may have come into the system without any formal registration. A close study of accidents involving spent or abandoned radiation sources throughout the world have revealed that they were not in safe custody or properly secured. Taking cognisance of these facts, the RPB instituted a program to locate and register the sources which had come into the country before the passage of the legislative instruments.

1.1. Security of radiation sources no longer in use

The experience gained over the years and training programs offered by the International Atomic Energy Agency (IAEA) helped the RPB in identifying some institutions and industries which were more likely to have in their possession these radioactive materials. Questionnaires were developed and sent to these institutions and industrial concerns. The answers to the questionnaire led to follow-up visits in some cases and finally to the retrieval of some sources which were no longer in use. Notable among these were

a) Strontium-90 sources for thickness gauging which were out of use in a cigarette factory
b) An abandoned beta source retrieved from a leather factory for thickness gauging [3]

c) A contaminated source of raw material for a plastic manufacturing company which was impounded with the help of CEPs and modalities put in place for export back to the country of origin [4].
d) A disused x-ray tube and an Ra-226 source at a university [5].

Table I gives the inventory of all sources not in use and taken into custody. Those still using radiation sources which were secured before the legislative instrument were also identified, registered and given the appropriate license for utilisation.

1.2. License for importation of radioactive materials and sources

The LI 1559 gives the RPB its legal framework and compels users, researchers as well as interested parties to obtain the appropriate license before importing the equipment for generation of ionising radiation or radioactive materials [6]. The contributions of the Customs Excise and Preventive Services (CEPs) who control the ports of entry into the country and the Environmental Protection Agency (EPA) which evaluates and grants licenses for the establishment of industries have been useful.

Table 1: Types and quantities of radioactive waste in storage at GAEC.

Nuclide	Type	Form	Activity (mCi)	Quantity
Sr-90	sealed	solid	4.0	5
Sr-90	sealed	solid	5.0	2
Sr-90	sealed	solid	2.0	2
Cd-109	sealed	solid	3.0	1
Ir-192	sealed	solid	5.0	1
Fe-59	sealed	solid	100.0	1
I-129	sealed	solid	125.0	1
Co-60	sealed	solid	1.0	1
Co-57	sealed	solid	1.0	1
Sr-89	sealed	solid	129.0	1
Ti-204	sealed	solid	1.0	2
Cs-137	sealed	solid	1.0	1
H-3	unsealed	liquid	10.0	10
Fe-59	sealed	solid	200.0	1
Sr-90	sealed	solid	10.0	10
P-32	unsealed	liquid	10.0	1
In-113m	unsealed	liquid	50.0	12
Cs-137	sealed	solid	9.0	5
Tc-99m	unsealed	liquid	153	6
Cf-252	sealed	solid	-	6
Ra-226	needles	solid	110mg	11

* Source spent inventory as per October 1996. Most of the waste have been conditioned and immobilized using cement.

1.3. Licensing provisions as a means of strengthening security

The RPB adheres to the basic principles of radiation protection namely:-

a) Justification of practice
b) Control of operations to exposure As Low As Reasonably Achievable (ALARA)
c) Maintaining dose limits within the set limits of the IAEA in its Basic Safety Standards [7] and in accordance with ICRP [8].

Before a license is granted all the basic principles are expected to be satisfied by the applicants in addition to other requirements such as :

a) adequate training of the operating staff
b) Provision of the requisite tools and equipment for operation
c) A workable emergency preparedness program that can be tested for mitigation of all possible scenarios of radiological emergencies
d) Scheme for disposal or otherwise of the radioactive materials after their useful life span
e) where a radioactive material is involved the waste generator may seek the help of the National Radioactive Waste Management Centre (NRWMC) to transport the waste to the Centre for storage in accordance with IAEA recommendations [9].

1.4. Verification of compliance and monitoring compliance as a security regulation

RPB carries out verification announced and un-announced visits to ascertain the operational status of the facility, adherence or compliance to safety procedures and emergency response activation mechanisms. The short comings of the visits are documented and submitted to the operating organisation. A time frame for which such a corrective action is to be taken is given. If the problem appears serious a temporary ban may be placed on the operating licence or otherwise revoked.

Apart from personal alarm monitors and pen dosimeters which may be used by the operating organisation, it is mandatory that thermo-luminesence dosimeters (TLD) issued to individuals by the RPB as part of the provisions of the license, be returned monthly for evaluation.

1.5. Impact of training courses

Training courses are organised for target operators of radiation facilities or equipment from time to time. These courses serve as a means of informing and/or refreshing personnel working in a radiation environment about the need to observe and follow laid down procedures in their day to day running of the facilities. The most probable emergency scenarios that may arise leading to overexposure of personnel in a radiation zone and how such a problem may be overcome are discussed. Assessment of effectiveness of national programmes for safety of sources show that they are very much patronised and has served as a bridging gap between technology transfer and industry.

2. Recommendations

To strengthen regulations on the security of sources, the following suggestions may be considered.

(i) Demarcating the country into smaller zones for more effective policing.
(ii) Information, awareness and documentary programs to educate the public on the effect of radiation on humans and the environment.
(iii) Training and provision of appropriate equipment to Custom Officials at the country's entry points.
(iv) Using regional and international organisations such as the OAU, EU, PAHO, FBI as an effective policing and enforcement bodies to prevent illegal transfers from one country to

another or across continents. The standardisation or harmonisation of radioactive transport regulations among regional member states are therefore highly recommended.

(v) Institution of severe punishments including jail terms (and without option of a fine) for persons involved in the illegal transport, trade, smuggling, etc. of radioactive materials across national and international boundaries.

3. Conclusion

The potential threat of unaccounted radioactive sources or materials to the public has greatly been subsided since the establishment of the RPB through its intensified efforts to secure and register these sources. The programmes followed and the assistance of such institutions like the police and the customs. The need to further strengthen the enforcement aspects and apply punitive sanctions to safeguard life through effective monitoring and co-ordination between regional and interegional bodies is recommended.

4. Acknowledgements

We wish to express our sincere thanks to the IAEA and the Government of Ghana (through the GAEC) for provision of grants and a forum to undertake the presentation.

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REQUIREMENTS APPLIED IN CUBA TO THE TRANSPORT OF RADIOACTIVE MATERIALS

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Abstract

The objective of this paper is to comment the supplementary requirements imposed by the Competent Authority to the operations of the main importing/delivering enterprise of unsealed sources for approvals and administration since the establishment, in 1987, of the legal framework on transport of radioactive materials. The paper summarizes the achieved results in this field in over 11 years of operation.

1. Introduction

Cuba imports all the radioactive materials used in the country. Three enterprises, specialized in contracting respectively sealed sources for gammatherapy (MEDICUBA), and for industrial gammagraphy (ENERGOIMPORT) and unsealed sources for medicine and research (ISOCOMER), import more than the 99% of the total activity used in the country and directly take part in the transport of the imported radioactive material to the national users.

The Competent Authority has been paying special attention to the operations of these three importing/delivering enterprises since the establishment, in 1987, of the legal framework on transport of radioactive materials [1]. In this regard, it was established a consequent policy in transport based on: the jointly participation of its inspectors and police forces in the transport of the sources with the biggest activities, the participation of the user's radiation protection officer as the one in charge of the transport of sources for industrial gammagraphy, and the establishment of supplementary requirements to the operations of the main importing/delivering enterprise of unsealed sources for approvals and administration. The present paper summarizes this policy in the case of the main importing/delivering enterprise of unsealed sources and shows its results in over 11 years of operation

2. Requirements to the operations of the main importing/delivering enterprise of unsealed sources

The main importing/delivering enterprise of unsealed sources for medicine and research carries out almost the 99% of the transport of Type A and excepted packages all over the country, which represents near the 80-90% of the total amount of transported packages. In 1987, these operations were carried out by the enterprise ENSUFARMA and in 1996 they were transferred to ISOCOMER.

The establishment of requirements by the Competent Authority to the operations of the main importing/delivering enterprise of unsealed sources for approvals and administration was based in the followings premises:

- Unsealed sources packaging imported in the country are mainly packaging Type A and excepted packages. In the international practice a non negligible level of cases of lost and theft corresponds to these packages . These events always represent an important problem because of the real possibility of a member of the public to access that package without recognizing the basic trefoil symbol of radioactivity in the label.

- The delivery of all the received packages is commonly carried out within the 48 hours after its reception in the airport, which implies that the enterprise should have a site for in-transit storage of the packages to be delivered.
- The enterprise might receive from the consignor not only package, but overpacks to be opened during in-transit storage for delivering the packages they enclose.
- For different reasons, there are packages that the enterprise has to retain. The enterprise should have a site for the interim storage of these packages. Before 1987, the use of inappropriate sites implied complex radiological situations.
- Regulatory control of the delivery operations of unsealed sources facilitates the execution of a more efficient control of imported materials and its use.

For granting the corresponding authorization to the operations carried out, in 1987 and in accordance with the above mentioned premises, the Competent Authority imposed to ENSUFARMA the following requirements:

<u>Use of vehicles for the transport of consignments under exclusive use</u> At the end of 1987, the enterprise already had two vehicles equipped with an enclosure which, during routine conditions of transport prevents the access of unauthorized persons to the interior and display the placard shown in the IAEA "Regulations for the Safe Transport of Radioactive Material" [2] on each the two external walls and external rear wall.

The driver's cabin in both vehicles was shielded with lead sheets in order to ensure dose rate to be lower than 20 μSv/h for the maximum load; in addition, inside the enclosure was established a clear distribution of the areas for packages of the different categories: the packages belonging to the Category III Yellow, commonly Mo^{90}-Tc^{99m} generator, occupy a limited area in the rear part of the vehicle, while the excepted packages and packages belonging to the Category I White are situated closer to the driver's area

The enterprise's vehicles are used for delivering packages addressed to users located in the capital of the country; 5 hospitals located within a radius of 250 km from Havana pick up their products by themselves in Havana and for the rest of the users national air shipment are used.

<u>Availability of an installation for the interim storage of packages</u> The interim storage installation of the enterprise began to operate in 1991, in an approximately 240 m^2 area one-floor building dedicated exclusively to this activity with the following distinctive facilities:

1. Room for the storage of unsealed sources, with floor and walls covered respectively with non-absorbing and easily-to-decontaminate material and paint. Of all the installation, this room occupies the biggest area and has induced ventilation through a unique exhaust system without filters and designed for the in-transit and the interim storage of generators, radiopharmaceuticals and others labelled compounds, the openings of the overpacks and the consignment's preparation.

2. Room for package decontamination, with floor and walls also covered respectively with non-absorbing and easily-to-decontaminate material. Divided into two sections, the room was designed for events such as the reception of damaged packages. The first section of the room has a table with washer and in the other one a fume hood is provided.

3. Access of personnel area, conducting to the above-mentioned rooms, conventionally designed, with shower.

4. Beside the unsealed sources storage room and directly conducting to it is located the area for package reception and eventual decontamination of the transporting vehicle with polished concrete floor, falling onto a central pipe run discharging to a retention system before passing to the common sewage.

In addition, the installation has a room for the storage of sealed sources, with polished cement floor, a concrete cast "in situ" 5x1x1 m hole and a 5 TM crane, designed to offer in-transit and interim storage service for gammatherapy sources. Finally, it is provided an office room for management control.

Working procedures The corresponding working procedures, required for the safe operation of vehicles, was submitted to the Competent Authority in 1987. These procedures included the reception of packages in the airport, its loading, carriage including in-transit storage, unloading and reception at the final destination. The procedure also included emergency provisions in the event of accidents or incidents during the transport of radioactive materials, programs for the technical maintenance of vehicles and the control of its technical response, transport documents, area monitoring and education and training of the personnel.

Dose rate and contamination monitoring For the practical implementation of the established procedures, the enterprises ensured for each vehicle the use of one dose rate monitor and another one for the surface contamination measurements.

Availability of a radiation protection officer In order to ensure safety during transport operations, a radiation protection specialist was officially designated as radiation protection officer of the enterprise to control the compliance with the working procedures and safety measures during the operations, i.e. the use of personal dosimeters, the performance of the necessary control and preventive monitoring of the vehicle and the storage etc.

Education and training of personnel The initial education and training of the personnel participating in transport operations in 1987 was performed by the Competent Authority. The education and training of personnel have been performed by the radiation protection officer in connection with other national institutions offering periodical courses in the field of radiation protection and service for specialized education of personnel.

3. Achieved results

Since 1987 the Competent Authority has been carrying out a compliance assurance program that, in relation with the main importing/delivering enterprise of unsealed sources, shows the following results:

- Inspections carried out by the Competent Authority show that no complex situation concerning radiological protection had taken place during in-transit and interim storage of package.
- It was observed a continuity in the activities developed by the two different enterprises due to the transference of specialized personnel, facilities and techniques together with the responsibility for the operations and the availability of working procedures that have been improved in the light of the reached experience.

- Although the transporting radioactive materials vehicles had been involved in accidents, generally these accidents had happened with no radioactive materials inside. Due to an accident it was necessary to discount a vehicle that fell from a 10 m high bridge with two excepted packages inside that were not damaged as result of the event.

- No damaged packages has been received; in the external surfaces of the packages no presence of radioactive substance exceeding the appropriate levels was observed.

- Neither one of the importing/delivering enterprises of unsealed sources has reached as carriers an acceptable level in the development and implementation of a quality assurance program

- Assessment and periodical monitoring of radiation doses to persons demonstrate that non relevant dose limits have been exceeded.

4. Perspective

A center specialized in the production of labelled compounds on the basis of imported radioactive material began recently to operate in Havana, the Isotopes Center (CENTIS) is the most relevant entity using unsealed sources in Cuba. Throughout an extensive licensing period it was clearly demonstrated the existence of an efficient radiation protection management in the installation and of highly qualified experts in this field that identify protection and safety as being of the highest priority. At the present, a significant part of the users' needs are satisfied by CENTIS products. This center is delivering by itself, according to the issued authorization, products to users in the capital while for the rest ISOCOMER is the delivering enterprise.

In the near future it is foreseen that ISOCOMER will transfer to CENTIS its delivering functions and will remain as the contracting party. Although the new transference could seem quite complex, the Competent Authority is not against it, not only because of the demonstrated managerial efficiency of the Radiation Protection Department in CENTIS, but also because of the following:

- CENTIS productions are being prepared in Type A and excepted packages and now the institution is seriously working on the organization and implementation of a quality assurance program providing adequate confidence in relation with the design, manufacture, preparation, consigning, loading, carriage including in-transit storage, unloading and reception at the final destination of loads of radioactive materials and packages.

- For in-transit and interim storage of imported packages, in CENTIS facilities are available with the similar technical conditions of the ones available in ISOCOMER, on the other hand, the transference of techniques and working procedures are ensured.

5. Conclusions

The establishment of technical requirements to the operations of the main importing/delivering enterprise of unsealed sources has allowed the Competent Authority to influence directly, in approximately 80-90% of the transport operations, on the practical compliance with the provisions of the regulations in force in the country. This, joined to the compliance assurance program in execution by the Competent Authority, provide 11 years of evidence that in Cuba the provisions of the regulations are met in practice and that an adequate level of safety in transport of unsealed sources is reached

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UKRAINIAN EFFORTS IN PREVENTING ILLICIT TRAFFICKING IN NUCLEAR MATERIALS AND OTHER RADIOACTIVE SOURCES

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Abstract

The Ukrainian efforts in preventing illicit trafficking in nuclear materials and other radioactive sources are described. Attention is paid for Ukrainian Government's Decree intended, in particular, to facilitate in establishing well-coordinated activities of the Ukrainian law enforcement bodies and other agencies involved, assigning the status of the main expert organization on illicit trafficking in nuclear materials to the Scientific Center "Institute for Nuclear Research", in developing the three-years Program on prevention illicit trafficking in nuclear materials and other radioactive sources on the Ukrainian territory as well as measures at the State and customs borders. The main directions provided by the draft Program mentioned are presented as well.

In Ukraine to some degree or another more than 10 state agencies and legal persons are involved in measures directed to the prevention of illicit trafficking in nuclear materials and other radioactive sources (hereinafter, illicit trafficking in nuclear materials). In this connection the problem of the interaction of parties involved has been of great importance since the very beginning of the efforts of the Ukrainian state executive authorities in this field. The additional acuteness of the problem in Ukraine arises from the fact that independent Ukraine had to build up a lot of State's structures over again and the process of responsibilities distribution in the field of combating against illicit trafficking in nuclear materials was carried out on the background of State's structures development and reforming with all consequences arisen.

The problems of illicit trafficking in nuclear materials are intimately associated with nuclear material physical protection, accounting and control regulating of which is a function of the Nuclear Regulatory Administration (NRA), the structural part of the Ministry for Environmental Protection and Nuclear Safety (MEPNS). Besides, the MEPNS is the Competent Authority and Point of Contact in the field of Physical Protection of Nuclear Material in Ukraine. So, it was naturally, that the NRA was charged with coordination of efforts of the relevant state authorities.

The increase of the frequency of illicit trafficking incidents in nuclear materials and other radioactive sources in Ukraine and growing terrorism threat resulted in the fact that Ukraine was faced the necessity for urgent measures to be taken in order to improve the coordination of the efforts of all parties involved.

The first important step made on the way to solve this problem was Cabinet of Ministers of Ukraine's Decree of March, 4, 1997 "On Establishment of the Procedure of Executive Authorities and Relevant Legal Persons Interaction in the Case of Radioactive Sources Detecting in Illicit Trafficking".

The principal provisions of this Decree are the following:

1. Establishment of the procedure for executive authorities and relevant legal persons interaction in the case of radioactive sources detecting in illicit trafficking. The given procedure defined in more detail a mechanism of interaction of all parties involved, established the priorities and a scheme of mutual data exchange, information exchange with international organizations as well as population informing in case of either nuclear material accidental detection or when its detection is a result of operational and investigation activities of law enforcement bodies.
2. Assignment the status of the main expert organization on illicit trafficking in nuclear materials to the Scientific Center "Institute for Nuclear Research" (Kiev). The high skilled research personnel of the given scientific institution had already carried out expert examinations of seized materials but the Decree tied up legally the status of the Scientific Center "Institute for Nuclear Research" to avoid the attempts of suspicious materials researching under improper conditions by unskilled personnel as well as established a legal base for updating and modernization the laboratories where analyses and expert examinations are carried out.
3. Instruction to elaborate and to submit to the Cabinet of Ministers of Ukraine the draft of the three-year Program on Prevention the Illicit Trafficking in Radioactive Sources on the Territory of Ukraine Until 2001. The draft of the above mentioned Program has been elaborated and contains provisions for the comprehensive approach to solve the problems of illicit trafficking in nuclear materials. The efforts provided by the draft Program shall be carried out in the following directions:

a) Necessary legislative base creation to prevent illicit trafficking in nuclear materials (development of the Design Basis Threat and the Models of Unauthorized Actions Against the Ukrainian Nuclear Objects, Procedure for Physical Protection Categorization in the Field of Radiation Sources Handling, Rules for Ensuring the Safety of Nuclear Materials and Other Radioactive Sources, Regulations on Responsibilities Distribution and Interaction Procedures for Executive Authorities, Organizations and Institutions Involved in Preventing Illicit Trafficking at State's Borders, etc.).
b) Equipping the main expert organization on illicit trafficking in nuclear materials with necessary equipment (creation of advanced fixed and mobile laboratories designed to analyze seized materials) as well as provision of relevant subdivisions of law enforcement bodies with necessary equipment and devices.
c) Development and introduction of the modern technical means for nuclear materials accounting, control and physical protection (development and preparation for industrial production of a portable spectrometer for carrying out the express analysis of the composition of radioactive material, organization of production of the security technical means basing on laser technologies, etc.). Measures specified in this item shall provide involving of the enterprises of the former defense industrial complex.
d) Measures at the State and customs borders directed to prevent the illicit trafficking in nuclear materials (providing the border crossing points, both road and railroad, with fixed radiation monitors, providing the road, railroad border crossing points as well as international airports with moveable search monitors designed for additional inspecting of suspicious items).
e) Information and analytical support of countermeasures against illicit trafficking in nuclear materials (development of the software and creation of the national computerized database on incidents related to the illicit trafficking in nuclear materials, development and putting into operation the automated control system for radiation sources transportation by motor vehicles).

f) Training and advanced studies for the officers and employees of law enforcement bodies and other agencies as well as legal persons involved. These activities shall be carried out, mainly, at the Ukrainian Radiation Training Centre (Kiev) and Training Centre on Nuclear Materials Accounting, Control and Physical Protection is to be completed in the nearest future on a base of the Scientific Center "Institute for Nuclear Research" (Kiev).
g) International cooperation in the field of preventing the illicit trafficking in nuclear materials.

The adoption of the above mentioned Decree bearing in mind Cabinet of Ministers of Ukraine's Decree of July, 30, 1996 "On Appointment a Central Authority and Point of Contact on Nuclear Material Physical Protection" created a sufficient legal base for Ukraine joining IAEA's program for collecting and sharing information on trafficking incidents involving nuclear materials. Ukraine fulfilled all necessary procedures in August 1997 and since that time has exchanged both open information and that with restricted distribution with relevant Agency's database.

Ukraine develops international cooperation in the field of preventing illicit trafficking in nuclear materials. In this field cooperation plans are elaborating not only with the IAEA but with EC (TACIS) as well. Specific Technical Terms of Reference for Technical Assistance Program "Providing effective assistance in counteracting against non-authorized transfer on nuclear material" were drafted and agreed with the European Institute for Transuranium Elements (Karlsruhe) and Finnish Center for Radiation and Safety (STUK) to be involved in these activities. In accordance with these projects provisions shall be made to assist Ukraine in developing regulative and methodological documents directed to preventing illicit trafficking in nuclear materials, in training for the specialists of the special subdivisions of law enforcement bodies and Customs Service and their equipping with the adequate tools, devices and protective means, in updating the equipment of the main expert organization in the field of the illicit trafficking, in carrying out joint analyses of seized materials.

It should be noted that there are many obstacles in Ukraine needed to be overcome in order to prevent illicit trafficking effectively. Both an economic situation and administrative reform under process make full scale introduction of the countermeasures against illicit trafficking difficult in Ukraine. Despite of the difficulties mentioned Ukraine intends with the assistance of international community to put the reliable obstacle for the illicit trafficking in nuclear materials and other radioactive sources being a serious threat not only to Ukraine but throughout the world.

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DISPOSITIONS PERMETTANT D'ASSURER LA SECURITE DES SOURCES DE RAYONNEMENTS IONISANTS AU SEIN DU MINISTERE DE LA DEFENSE

(Dispositions to secure ionizing radiations sources in the french defense ministry)

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Abstract

Radiation sources used by the French Ministry of Defence are under a statutory surveillance. Different type of sources are bound by authorisation, acquisition and utilisation procedures coming from the French common law. Systematic and periodic controls are ruled by decree.

Radiation sources used by all the organisations of the French Ministry of Defence are indexed by the S.P.R.A.(Army Radio Protection Service). The necessary stages for acquisition, possession, utilisation and elimination of each source may be controlled by the S.P.R.A.

Resume

Les sources de rayonnements ionisants, utilisées par le ministère de la défense français, font l'objet d'un suivi réglementaire. Les différents types de sources sont soumis aux procédures d'habilitation, d'acquisition et d'utilisation du droit commun français. Les contrôles systématiques et périodiques répondent aux critères fixés par décret.

Le Service de Protection Radiologique des Armées détient le fichier central des sources de rayonnements ionisants utilisées dans les organismes relevant du ministère de la défense. Il dispose d'un pouvoir de contrôle sur toutes les étapes nécessaires à l'acquisition, la détention , l'utilisation et l'élimination d'une source de rayonnements ionisants.

1. Introduction

Les dispositions permettant d'assurer la sécurité des sources de rayonnements ionisants au sein du ministère de la défense français, sont affirmées dans un texte réglementaire : *l'instruction ministérielle 33679/DEF/CAB/C/1/A du 19 octobre 1988.*

Outre la radioprotection médicale des personnels de l'ensemble du ministère de la défense, le Service de Protection Radiologique des Armées (SPRA), organisme du Service de Santé des Armées, a dans ses attributions la responsabilité du contrôle de l'acquisition à l'élimination des sources de rayonnements ionisants.

Pour remplir cette mission, il dispose d'un bureau "Sécurité Physique" et d'un service expert technique appartenant à la Délégation Générale pour l'Armement (DGA). Le SPRA est en outre, l'interface entre le ministère de la défense et les autorités civiles compétentes dans ce domaine.

2. De l'acquisition a l'elimination des sources de rayonnements ionisants.

2.1 Les différents types de sources utilisées dans la défense.

Les sources de rayonnements ionisants se répartissent en quatre catégories selon la classification en usage :

a) générateurs électriques de rayonnements ionisants, accélérateurs de particules hors usage médical ;
b) sources radioactives scellées et non scellées hors usage médical ;
c) générateurs électriques de rayonnements ionisants, accélérateurs de particules à usage médical ;

d) sources radioactives scellées et non scellées à usage médical.

L'acquisition, la détention et l'utilisation de ces sources sont soumises à des procédures strictes, propres à chacune des catégories.

2.2. Procédures d'habilitation, d'acquisition et d'utilisation.

2.2.1. Générateurs électriques de rayonnements ionisants et accélérateurs de particules hors usage médical.

Le SPRA est saisi de tout projet d'acquisition ou de mise en place d'un générateur. L'organisme acquéreur adresse un dossier technique complet accompagné d'une demande d'agrément d'installation non médicale de source de rayonnements ionisants.

Après étude du document, le SPRA autorise ou non la mise en œuvre des travaux d'infrastructure et d'installation. La mise en service ne peut être effective qu'après un contrôle initial par le service expert technique et l'accord du SPRA.

2.2.2. Sources radioactives scellées et non scellées hors usage médical.

L'acquisition, la détention et l'utilisation de ce type de sources de rayonnements ionisants, se conforment à l'article L632 du code de la santé publique et font l'objet d'une habilitation de la Commission Interministérielle des RadioEléments Artificiels (CIREA).

L'utilisateur constitue un dossier technique qu'il adresse au SPRA et dans lequel figure, en particulier, la nature de l'activité et les conditions d'emploi des sources. Le SPRA transmet alors tout ou partie de ce dossier à la CIREA. L'utilisateur ne peut commander de source qu'après agrément de la CIREA et du SPRA. Ces deux organismes s'informent trimestriellement à l'aide du "récapitulatif des fournitures de radioéléments artificiels au ministère de la défense".

2.2.3. Générateurs électriques de rayonnements ionisants et accélérateurs de particules et sources radioactives scellées et non scellées à usage médical.

Les procédures d'acquisition, d'habilitation, de détention et d'utilisation obéissent aux même règles que celles fixées pour les usages non médicaux. A ces procédures, s'ajoute une demande d'agrément que le SPRA transmet à l'Office de Protection contre les Rayonnements Ionisants (OPRI). Ce dernier attribue à l'utilisateur un numéro d'agrément autorisant le remboursement des actes par la sécurité sociale.

2.3. Contrôles systématiques et périodiques des sources de rayonnements ionisants.

Les opérations de contrôle sont effectuées sur demande du SPRA par :

- son bureau "Sécurité Physique" ;
- le service expert technique de la DGA.

Ces contrôles portent sur les sources de rayonnements ionisants et sur leurs dispositifs de sécurité radiologique.

Les contrôles sont systématiques avant la mise en service de sources, en cas de modification de l'installation, de dépassement d'une des limites annuelles d'exposition par un opérateur et de cessation définitive d'emploi dans le cas des sources non scellées.

Conformément au décret 86-1103 du 2 octobre 1986, les sources de rayonnements ionisants font l'objet d'un contrôle périodique défini.

Chacun de ces contrôles donne lieu à l'établissement d'un compte-rendu qui est adressé au SPRA. L'autorisation d'utilisation est accordée ou non par le chef du SPRA au vu des résultats. Une copie du compte-rendu est adressée à l'OPRI si l'installation est à usage médical.

2.4. Elimination des sources de rayonnements ionisants.

Les générateurs électriques et les accélérateurs de particules, à usage médical ou non, sont éliminés selon des procédures propres au ministère de la défense. L'utilisateur a obligation d'adresser au SPRA un compte-rendu de mise hors service de l'installation.

Les sources radioactives scellées, périmées ou retirées du service peuvent être évacuées par le fournisseur ou reversées à l'Agence Nationale pour la gestion des Déchets Radioactifs (ANDRA). Le SPRA est destinataire d'un compte-rendu d'élimination et veille à l'information de la CIREA qui tient une comptabilité pour chaque habilitation.

3. Modalites pratiques du suivi et du controle des sources de rayonnements ionisants au sein du ministere de la defense.

Le SPRA élabore et tient à jour le fichier central des sources de rayonnements ionisants utilisés dans les organismes relevant du ministère de la défense. Il veille à l'application des procédures réglementaires pour l'acquisition, la détention, l'utilisation et l'élimination des sources de rayonnements ionisants. Il prescrit et élabore le calendrier des contrôles systématiques et périodiques.

3.1. Le fichier central des sources de rayonnements ionisants.

Chaque établissement de la défense est identifié sous un numéro et fait l'objet d'un dossier d'établissement. Chaque source de rayonnements ionisants est considérée comme une installation et fait l'objet d'une identification individuelle. Les sources sont gérées par établissement.

Le dossier d'établissement comporte un dossier technique et pour chaque installation une copie des différentes autorisations d'acquisition et de détention, une copie des différents documents émis à l'issue des contrôles systématiques et périodiques.

Le dossier technique comporte obligatoirement un descriptif détaillé du local de stockage de chaque source, les caractéristiques de la protection radiologique, les moyens de détection radiologique et les moyens de prévention contre la malveillance, le vol et l'incendie. Le SPRA est par ailleurs averti sans délai de tout vol ou perte de source.

L'ensemble des données qui permettent de suivre une source de rayonnements ionisants, de son acquisition à son élimination, de la contrôler aux échéances réglementaires, de veiller à sa sécurité sont disponibles sur une application informatique en cours de développement par le SPRA.

Le fichier central des sources de rayonnements ionisants de la défense peut être communiqué, en tout ou partie, aux autorités civiles et militaires qui ont à en connaître.

3.2. Les contrôles.

Les contrôles systématiques et périodiques sont fixés par le SPRA. Ils donnent lieu à l'établissement d'un programme annuel pour les contrôles périodiques et à une décision pour les contrôles systématiques conformément à la réglementation.

Réalisés généralement par le service expert technique de la DGA et en collaboration avec les bureaux "Sécurité Physique" et "Radioprotection Médicale" ainsi que le laboratoire de contrôle radiotoxicologique du SPRA quand la situation l'exige, les contrôles comportent un aspect technique et un aspect administratif.

Si les contrôles techniques répondent à des exigences précises, les contrôles administratifs s'attachent à la vérification de la permanence des différents éléments de sécurité décrits dans le dossier d'établissement et en particulier l'identification de la Personne Compétente en Radioprotection (PCR), des titulaires du Certificat d'Aptitude à Manipuler des Appareils de Radiologie à usage Industriel (CAMARI). Le SPRA veille scrupuleusement au respect des habilitations et des déclarations faites auprès de la CIREA et de l'OPRI. Il a autorité pour interdire toute utilisation de source de rayonnements ionisants en cas de non respect d'un seul critère de sécurité, d'autorisation d'acquisition, de détention et d'utilisation.

3.3. Rôle du SPRA dans les procédures d'élimination.

Le SPRA a pour mission, d'élaborer et de rechercher les filières d'élimination des matières radioactives pour le compte du ministère de la défense.

Les générateurs électriques font l'objet d'une déclaration d'élimination. Après neutralisation des dispositifs actifs, ils sont éliminés selon des procédures propres à chaque armée utilisatrice.

Les sources radioactives, selon leur nature et leur ancienneté sont soit reprises par le fournisseur, soit adressées à l'ANDRA, selon des procédures propres à cet organisme.

Le SPRA veille à ce que les organismes tels l'OPRI et la CIREA, soient avertis de la cessation d'utilisation des sources, chacun pour ce qui le concerne. Après retrait d'un générateur électrique ou d'une source radioactive, le dossier de l'installation est archivé au SPRA.

4. Conclusion

Le suivi et le contrôle des sources de rayonnements ionisants sont assurés, au sein du ministère de la défense, selon les règles de droit commun de l'Etat français.

Le Service de Protection Radiologique des Armées est un organisme central doté d'un pouvoir de contrôle de toutes les étapes de la vie d'une source de rayonnements ionisants. Il participe activement, en collaboration avec les utilisateurs et les autorités civiles concernées, à la sécurité des sources de rayonnements ionisants appartenant au ministère de la défense.

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THE PREVENTING OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIALS IN ESTONIA

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Abstract

This paper explains the situation of legislation, practical border-control and equipment of different relevant authorities dealing with the control of radioactive materials in Estonia. The overview of legislation concerning radiation and radiation protection is given. The roles of Estonian Customs Authority, Estonian Border Guard, National Rescue Board and Police Authority in the preventing of illicit trafficking of radioactive materials are shown. The incidents of illicit trafficking of radioactive materials are listed. Also the most important border-crossing points and the types of equipment used there are shown. Finally the problems of controlling the borders in Estonia and the future plans in order to make the controlling system more efficient are discussed.

1.Legislation concerning radiation and radiation protection

Estonian radiation protection act was adopted by Estonian Government on the 23rd of April 1997 and it entered into force on the 16th of May in 1997. The main task of this act is to protect public and environment against the hazards of radiation. At present there are 4 ordinances implemented in Estonia for the application of Estonian radiation protection act. Two ordinances are just in draft. One of them is the ordinance establishing the order of transportation of radioactive substances, devices containing radioactive substances and radioactive waste. These all must be implemented in Estonia helping to regulate the rules of transportation of radioactive materials.

According to radiation protection act Estonian Radiation Protection Centre (ERPC) is the competent authority in filling the tasks regarding radiation practices and protection. In relation to radiation protection the state is responsible for:

- Issuing authorizations for any practice involving radiation and type approvals
- Keeping of the Dose Register and the Source Register
- Safety assessment of radiation level and radiation monitoring
- Notification on radiation accidents/incidents
- Implementation of international conventions and agreements
- State supervision.

2.Co-operation between the ERPC and other relevant authorities, which are responsible for the security of radioactive materials

The ERPC does co-operation with Estonian Customs Authority (ECA), Estonian Border Guard (EBG), National Rescue Board (NRB) and Police Authority (PA). The ECA and the EBG are responsible for the controlling of transport and people on the borders of Estonia.

According to Estonian customs act the ECA manages radiation source as one of the special goods requiring the authorization. In case of breaching the regulations established by the ECA the person must pay penalties or when it is considered a criminal act, then the person is given to the PA. The inspectors of the ECA are checking mainly hardware-metalcargoes, other goods are checked occasionally. The inspector must carry radiation dose rate meter with him while checking.

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Figure no 1 The map of Estonia

Also there are carried out checks of some other suspicious packages, but it depends on the inspector. According to instructions given by Board of the EBG it is obligatory to check all the incoming traffic, especially on eastern border. As there are no legally regulated normatives of radiation safety in Estonia, in the practical work the inspector must arrest these shipments, which the radiation level on the outer surface is 0,3 μSv/h or higher. When such high radiation level is discovered the inspector has to inform quickly the NRB, who is responsible for the further operations to avoid hazards of radioactive source or sources. The NRB must arrange the identification of source and the transport of source if necessary. Mainly the NRB is obliged to arrange the safe transport and storage of radioactive sources, if any is discovered on the border-crossing point or in any other place of the country. The trafficker is arrested and is given to the PA, who must decide whether there's a need for criminal act or not. The cases of illicit trafficking of radioactive materials are listed in table no I. Last year (1997) only one case of illicit trafficking was reported.

3.Estonian border-crossing points and equipment used by the ECA and the EBG.

The most important border-crossing points as it is seen on the map are provided with stationary dose rate meters. In smaller places portable dose rate meters are used. The map of Estonia is shown on figure no 1.

Table no I Incidents of illicit trafficking of radioactive materials in Estonia

No	Date	Location	Object	Quantity
1	1993/03/29	Kohtla-Järve	Caesium-137	0,17 TBq
2	1993/04/01	Narva	Caesium-137	0,26 TBq
3	1993/07/02	Tallinn	Caesium-137	66 GBq
4	1994/01/14	Tallinn	Caesium-137	1,6 TBq
5	1994/08/17	Põlva	Low enriched uranium-235	
6	1994/09/28	Tallinn	Caesium-137	66 GBq
7	1994/11/18	Kiisa	Caesium-137	1,8 TBq
8	1995/01/14	Valgejõe	Caesium-137	3,1 TBq
9	1995/05/10	Tallinn	Depleted uranium	
10	1995/07/07	Tallinn	Caesium-137	34 GBq
11	1995/07/24	Tallinn	Radium-226	3,4 MBq

Table no II The main border-crossing points and the equipment of the ECA in these points

Name of place	Type of radiation dose rate meter
Narva road	PRM-470A, portable
Narva pavilion for foot passengers	RDA-31, 1 portable is reconstructed to stationary one-Geiger-Mueller type
Narva railway	RM-5303-01, stationary
Orava railway	RM-5303-01, stationary
Koidula road	RM-5303-01, stationary
Valga pavilion for foot passengers	TSA VM-250, stationary
Valga road	RDA-31, 1 portable is reconstructed to stationary one- Geiger-Mueller type
Ikla road	RM-5303-01, stationary

The ECA has 37 portable dose rate meters and 5 stationary radiation monitoring systems: 4 of type RM-5303-01 and 1 of type TSA VM-250. Nine portable dose rate meters, named PRM-470A are able to detect nuclear materials from neutron radiation. The main border-crossing points and the equipment of the ECA used there are listed in table no II.

The EBG is equipped with radiation dose rate meters as follows:

—portable Micro R Meter Ludlum Model 12SA: 50 pieces

—stationary Radiation Monitoring Systems designed for heavy vehicles:

Ludlum Model 3500-23   1 system   on the road to Narva

Ludlum Model 3523   1 system   on Luhamaa road

These radiation dose rate meters are presented on the borders of Estonia as follows:

1. Eastern border with Russia: 22 portable radiation dose rate meters
   2 stationary radiation monitoring systems
2. Southern border with Latvia: 10 portable radiation dose rate meters
3. Nothern coast and border checking points of Tallinn: 11 portable radiation dose rate meters
4. Border Guard regions on Saaremaa and Hiiumaa: 5 portable radiation dose rate meters
5. Border Guard training centres: 2 portable radiation dose rate meters.

One stationary radiation monitoring system named BICRON belongs to EMEX Ltd., which is the largest enterprise dealing with scarp metal transportation in Paldiski southern port.

It is planned to provide Tallinn Airport with complete radiation monitoring system during the reconstruction using the help of Finland and especially Finnish Radiation and Nuclear Safety Authority (STUK), who gave financial and technical support.

4.The future plans for better control of illicit trafficking of radioactive materials

There is no legitimate procedures for the prevention of illicit trafficking of radioactive materials in Estonia. For example accepted radiation level for vehicles crossing the border, division of labour on the border etc. So there is a need for a legal act establishing the radiation level higher from which to punish or to start a criminal act. At present in Estonia any trafficker is not yet punished due to the absence of legal act.

Currently used portable Geiger-Mueller type dose rate meters have to be changed with more sensitive and neutron radiation detectors. There is unsufficient control of foot-passengers in Estonia. There is a need for stationary radiation monitoring system for checking foot passengers and their luckage. Some of the currently used portable dose rate meters are uncomfortable due to their large size and weight. In future there are plans to change some radiation dose rate meters and to install to some border-crossing points new ones. For example in ports the control of radioactivity is unsufficient.

One problem is the unsufficient qualification and poor knowledge of personnel today concerning to radioactivity, techniques and checking. The inspectors of the ECA have to pass only one training course regarding radiation protection. It is about theoretical bases of radiation, applicable regulations and the use of radiation dose rate meters. The ECA has also two radiation sources for training purposes.

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PROTECTION AND CONTROL OF NUCLEAR MATERIAL IN FRANCE

R.VENOT

No paper available for printing

SECURITY OF RADIOACTIVE SOURCES AND MATERIALS

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Abstract

The activities involving the use of radiation sources and radioactive materials are subject to the control of the national bodies dedicated to the nuclear regulation. The main objective of this control is to assure an appropriate level of radiological protection and nuclear safety.[1]

In Argentina, this function is carried out by the 'Nuclear Regulatory Authority' (ARN) whose regulatory system for radiation sources and radioactive materials comprises a registration, licensing and inspection scheme. The system is designed to keep track of such materials and to allow taking immediate corrective actions in case some incident occurs.

Due to the appearance of a considerable number of illicit traffic events involving radiation sources and radioactive materials, the specialized national and international community has begun to evaluate the adoption of supplementary measures to those of "safety" guided to its prevention and detection (i.e. 'security measures').

This paper presents a view on when the adoption of complementary 'security' measures to those of "safety" would be advisable and which they would be. This will be done through the analysis of two hypothesis of illicit traffic, the first one with sources and radioactive materials considered as "registered" and the second, with the same materials designated as "not registered." It will also describe succinctly the measures adopted by the ARN or under its analysis regarding the 'security' measures to sources and radioactive materials.

1. Introduction

To the aim of this work, the term "radiation sources and radioactive materials" does not refer to nuclear materials. 'Registered' radiation sources and radioactive materials are those subject to the control of the nuclear regulatory bodies. Those "not registered" are the ones involved in movements across the borders or inside them that can happen without the knowledge and control of the competent authorities of the relevant States.

The present study will consider for illicit traffic of radioactive materials: 'The unauthorized receipt, provision, use, transfer or disposal of radioactive materials, whether intentional or unintentional and with or without crossing of international borders.[2]

The illicit traffic of 'not registered' sources and radioactive materials constitutes the area of more concern, since it involves radioactive materials that would not be known by the relevant control bodies. Therefore, the adoption of 'security' measures (i.e. extrapolated from the physical protection system) that allow preventing and detecting such illicit traffic and thus mitigating its potential radiological consequences will be considered.

2. The Argentinean regulatory system for sources and radioactive materials

There are about 1500 facilities that use radiation sources and radioactive materials in Argentina. These facilities use such materials with different purposes, such as radioisotopes production, basic and applied research and medical or industrial applications. The complexity

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[1] Nuclear material is also subject to control by the ARN in connection with the 'Guarantees of Non Proliferation' and Physical Protection.

[2] This definition is included in the 'IAEA Safety Standard Series – Draft Safety Guide: Preventing, Detecting and Responding to Illicit Trafficking in Radioactive Materials'

of the facilities as well as the radioactive inventory in the country embraces a wide range and geographical distribution, counting in the order of 5500 registered sources.

The ARN grants authorizations and licenses and enforce regulatory requirements, as applicable, to any practice involving radiation sources and radioactive materials. After granting such licenses the ARN verifies that each practice is performed in compliance with all national standards and international commitments adopted by the Country through the conduct of inspections and audits.

Concerning the 'safety' of radiation sources and radioactive materials, the ARN has issued the Basic Standard on Radiological Safety (Standard AR 10.1.1), that besides fixing rules, recommendations and requirements for the users of such materials, it has incorporated the recommendations issued by the International Commission on Radiological Protection ("ICRP"). In connection with their transport, Argentina has adopted the recommendations of the Safety Series. 6 of the IAEA on "Safe Transport of Radioactive Materials."

3. 'Registered' and 'not registered' radiation sources and radioactive materials - Illicit traffic

The adoption of complementary 'security' measures would have for objective to enhance the capability of preventing and detecting the illicit traffic of radioactive materials. These measures would assist in preventing the commission of intentional or unintentional acts that can lead to severe radiological consequences. Therefore, the measures of 'security' are clearly subordinate to those of 'safety'.

A first analysis of the known illicit traffic events shows that their probability of occurrence in Argentina and in Latin America region is relatively low. However, considering the cases registered in other regions of the world, the ARN has included this issue some time ago in its medium and long-term assessments.

3.1. Hypothesis of illicit traffic of 'registered' radiation sources and radioactive materials

As it was mentioned, the main purpose of the registration and inspection system is to maintain the knowledge of the sources and radioactive materials and to assure a prompt detection and the application of immediate corrective actions in case some incident occurs.

The above mentioned system has been deemed satisfactory to assure an appropriate level of people's protection against the noxious effects of ionization radiation and to achieve and maintain a reasonable degree of radiological and nuclear safety. However, having in mind the appearance of events linked with the "nuclear crime" (i.e. theft, terrorism or sabotage) with sources or radioactive materials, the query of whether it is necessary to adopt complementary 'security' measures needs to be answered in the near future.

In Argentina, "registered" sources and radioactive materials are subject to the regulatory system briefly described in point 2, so the commission of an illicit act with them would be prevented by this system. In the event of not being prevented, the system would allow its detection and the implementation of immediate corrective actions. Therefore, it would not be necessary to adopt 'security' measures in addition to those of radiological protection in place.

Nevertheless, events like theft or sabotage against facilities with high radioactive inventories [e.g., of the order of 37 PBq (10^6 Ci) of ^{60}Co] might be considered as special cases. Similar consideration would be applicable to such actions directed to the transport of radioactive materials with a significant activity within a State. This would indicate the convenience of adopting some measures of 'security' supplementary to those of 'safety'. These measures would be defined through the evaluation of the possible radiological consequences that such intentional acts could cause.

Therefore, in installations with a high radioactive inventory, it would be advisable to consider the implementation of some measures of the System of Physical Protection (PPS); similar to those applied in facilities with nuclear material.[3]

Similarly, for the transport of sources and radioactive materials, the convenience of applying some 'security' measures in addition to those of "safety" for preventing or detecting such illicit acts should also be examined. In particular, when this transport involves sources and radioactive materials of a given activity. A case under study of the ARN refers to the transport of ^{60}Co, since Argentina is one of the main producer of ^{60}Co and it regularly carries out transports of such material, each involving of the order of 55 TBq (1.5 x 10^6 Ci) of ^{60}Co.

In conclusion, the analysis of possible criminal events (e.g., sabotage) against 'registered' radiation sources and radioactive materials, shows that the adoption of some "security" measures, would be advisable in very specific cases. The measures to be implemented will correspond to the evaluation of the possible radiological consequences that such intentional acts could cause.

3.2. Hypothesis of illicit traffic of 'not registered' radiation sources and radioactive materials

The "not registered" radiation sources and radioactive materials constitute the biggest challenge to be considered, because they refer to those for which there is not knowledge and thus they would be out of the control system. Therefore, the existence of additional "security" measures would allow enhancing the capability of prevention and detection of such materials. That will increase the possibility of taking actions to mitigate the potential radiological consequences derived from an illicit act (theft, sabotage or terrorism).

Those measures would consist primarily on the adoption of a system which permits taking timely knowledge, through normative and operative procedures and especially, through the exchange of information with other national and international control bodies properly coordinated with the nuclear regulatory authority.

Despite the low probability of illicit trafficking in the region, it is not possible to exclude the entrance of radiation sources and radioactive materials to the national territory, either intentional or not, out of the control of the relevant authorities. No Country is completely exempted of being used as a transit place to illicit trafficking radiation sources or radioactive materials toward or from other Countries. Neither the possible entrance of radioactive sources as if they were conventional goods nor the simply loss of knowledge due to an administrative failure can be underestimated (e.g. steel, metal scrap, etc.).

Consequently, the ARN in coordination with the Customs Authority and security bodies, has foreseen the adoption of 'security' measures, to assuring the prevention and early detection of this events, in order to place those sources or radioactive materials under its regulatory control ('safety').

As a result of the analysis of possible illicit events that involve 'not registered' radiation sources and radioactive materials, it is advisable to adopt some extrapolated practices of those of physical protection for nuclear materials. Basically, measures related with i) prevention, ii) legislation and regulation, iii) training, iv) response, and v) exchange and coordination of the information.

4. Measures to cope with the illicit traffic of nuclear materials - Possible application to the illicit traffic of sources and radioactive materials

In the last years, some incidents derived from movements of nuclear material and other radioactive sources among States have happened, without the intervention and control of the

[3] The Argentine requirements of the Physical Protection System are specified in the Standard AR.10.13.1 (Basic Standard of Physical Protection of Nuclear Materials and Installations).

competent bodies. In several cases, that was due to the absence of appropriate nuclear regulatory infrastructures or insufficient mechanisms of control.

The international community is carrying out an intensive program to prevent situations that involve the illicit traffic of nuclear materials in order to minimize the risk of proliferation of nuclear weapons. Nevertheless, no significant events with these materials had happened. Most of the known illicit traffic cases involved radiation sources and radioactive materials. Radioactive materials such as the ^{60}Co or the ^{137}Cs have been offered to sale out of the control system. Some radiation sources have been confiscated from individuals not authorized for their possession.

Therefore, the ARN is executing different activities in the fields of prevention, legislation, response, training and exchange of information. In addition, being ahead to the emergent spirit of the underway revision of the INFCIRC 225/Rev. 3, the ARN is studying the consequences of acts of sabotage involving radioactive materials.

4.1. Prevention

The ARN has established a system of physical protection for nuclear materials to prevent the commission of intentional acts that can lead to severe radiological consequences. Recently, the ARN have adopted additional measures to strengthen the current system to prevent and detect the illicit handling or use of such materials. On the other hand, although with a different objective, the ARN has put in place a system of accounting and control of nuclear materials (safeguards). Both regulatory branches are supplemented for the execution of their objectives.

Besides the existing notification, registration, licensing and inspection infrastructure, the ARN is studying to adapt some measures of the physical protection system of nuclear materials to the radiation sources and radioactive materials. The routine exchange of information with the Customs Authority and Security bodies takes place regularly. In addition, it is under the ARN's study the installation of radiation detectors (mobile and fixed) to be located for instance at border control stations, airports, ports of entry, etc.

4.2. Legislation and regulation

Recently, the National Congress has approved the 'National Law of Nuclear Activity' (Law Nro.24804), which provides that the regulatory and control functions of the ARN to all nuclear activities in the areas of radiological and nuclear safety, physical protection and guarantees of non proliferation are aimed to:

- Protect people against the noxious effects of ionization radiation,
- Look after the radiological and nuclear safety in the activities carried out in the country,
- Assure that nuclear activities are performed in compliance with the Law, the regulatory standards and requirements and all the international commitments and non proliferation policies assumed by the country, and
- Prevent the commission of intentional acts that can lead to severe radiological consequences.

The Law foresees among the functions and obligations of the ARN:

- To establish procedures for the application of sanctions for the violation of the standards issued by the ARN to fulfil its responsibilities, assuring the principle of due process.
- To confiscate nuclear and radioactive materials and to close preventively any installation that carries out a practice with these materials without the due license, permission or authorization or in the presence of serious violations to the radiological and nuclear safety standards.

4.3. Training

One of the objectives of the ARN is the continuous improvement of its control system, being the training an important tool to achieving it. Thus, the ARN carries out specific courses for the users of radioactive materials and for the personnel of the organisms involved in the control of the entrance or exit of radioactive materials (e.g. Customs Authority, Security forces, etc.). Among them:

- The Physical Protection and Prevention of Illicit Traffic course for the National Custom staff (more than 200 officials). It included topics as the interaction of the radiation with the substance, radiological protection, transport of radioactive materials, physical protection, prevention of the illicit traffic of materials, response before emergencies and detection of radioactive materials.
- Similar training courses directed to the security forces, such as the Air Force Police (PAN), the Naval Prefecture (PNA) and the National Gendarmerie (GNA), those that will continue being offered in next years.
- Under the auspices of ICPO-INTERPOL and the Federal Police of Argentina (PFA), a Seminar on the Investigation of the Nuclear Crime, Physical Protection of Nuclear Materials and Prevention of its Illicit Traffic", was dictated by the ARN. The Seminar was dedicated to training the superior personnel's of the PFA, the Custom Administration (ANA) and the national Intelligence Services. Conferences about nuclear crime organizations, INTERPOL communications, nuclear weapons, non-proliferation guarantees, export and import controls were also included.
- Through the Program of Technical Cooperation of ARCAL, a Regional Course for Latin America and the Caribbean on Physical Protection of Nuclear Materials and Facilities will take place between 1999/2000.

4.4. Response

The responsibility of implementing an appropriate system of physical protection concerns to each State and under it, to detect and to investigate any incident of illicit traffic that involves nuclear materials. The response of the system should be such that permits to react timely to the illicit act or to mitigate its consequences. It should also be noticed that the adequacy of a System of Physical Protection regarding the illicit traffic of nuclear materials also is of concern to the international community. The 'security' measures of this system adapted for the sources and radioactive materials should be equally capable to prevent their illicit traffic.

In this context, the ARN has begun to elaborate a guide directed to national authorities and specifically to border officials, on the procedures to be used for the detection of illicit movements of radioactive materials and the corresponding response after such detection.

4.5. Exchange of information

The exchange of information and frequent contact among relevant organizations, directly or indirectly related with this matter, is fundamental for the prevention and detection of the illicit traffic of radioactive materials. Hence, the ARN maintains a permanent contact with the National Customs Authority, the security forces, ICPO-INTERPOL, the World Organization of Customs (WOC) and the IAEA.

In the international context, several technical meetings related to the illicit trafficking of radioactive materials have taken place under the auspices of the IAEA. Many Member States, EUROPOL (European Police) and the World Customs Organization have participated.

The IAEA has established a database to record any illicit traffic involving radiation sources and radioactive materials. At the same time, the IAEA invited the Governments to indicate its interest of to participate in this program and to identify a contact point. Argentina has actively participated in such initiatives.

5. Conclusions

- The "security" measures that can supplement those of 'safety' have for foundation to strengthen the objectives of the radiological protection. Therefore, the 'security' measures in themselves are not relevant but for reason of assuring such objectives.
- It is considered appropriate that the 'security' measures to be established should be proportional to the radiological consequences that an illicit act with sources and radioactive materials could cause. The extrapolation of the measures of physical protection to radiation sources and radioactive materials should be adapted then to this approach.
- For the 'registered' sources and radioactive materials, it would be advisable to consider some complementary measures of "security" (similar to those of physical protection for nuclear materials) for the facilities and transports that involve radioactive materials above a given threshold.
- As for the illicit traffic of 'not registered' radiation sources and radioactive materials, the exchange of information and the permanent coordination of the nuclear regulatory body with all other related organizations are essential. The training is also important for the prevention, detection and response of possible illicit traffic events.
- In both hypotheses ('registered' and 'not registered' radiation sources and radioactive materials), it is very important to count with a solid nuclear regulatory infrastructure and with appropriate and consistent legislation to assure an effective control of such materials. Equally important is the international cooperation among the organizations related with the control of radiation sources and radioactive materials.

DETECTION AND IDENTIFICATION TECHNIQUES FOR ILLICITLY TRAFFICKED RADIOACTIVE MATERIALS

(Technical Session 8)

Scintillating-Glass-Fiber Neutron Sensors, Their Application and Performance for Plutonium Detection and Monitoring

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Abstract

Most neutron detection sensors presently employ ^{3}He gas-filled detectors Despite their excellent performance and widespread use, there are significant limitations to this technology A significant alternative neutron sensor utilizing neutron-active material incorporated into a glass scintillator is presented that offers novel commercial sensors not possible or practical with gas tube technology The scintillating optical fiber permits sensors with a multitude of sizes ranging from devices of a single fiber of 150μm to sensors with tens of thousands of fibers with areas as large as 5m^2 depending on the neutron flux to be measured A second significant advantage is the use of high-speed electronics that allow a greater dynamic range, not possible with gas detectors These sensors are flexible, conformable and less sensitive to vibration that optimizes the source-to-detector geometry and provides robust performance in field applications The glass-fibers are sensitive to both gamma rays and neutrons However the coincidence electronics are optimized for neutron to gamma ray discrimination allowing very sensitive measurements with a low false-alarm rate Applications include SNM surveillance, material control and accountability (MC&A), safeguard inspections, Pu health physics / bioassay and environmental characterization

1 Background

The concept of scintillating-glass-fiber neutron sensors have been proposed in the literature since the 1960's [1-4], but have not been commercially available because of technical difficulties in producing fibers with good optical qualities that also provided high efficiencies for thermal neutron capture Oxford Instruments has acquired innovative neutron sensitive glass fiber technology under license

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from Pacific Northwest National Laboratory (PNNL) and the U S DOE and is designing and manufacturing a variety of commercial products During the last decade PNNL has fabricated cerium-activated lithium silicate scintillating fibers with an operational transmission length (e^{-1}) of over 2m

2 Technology

The basic nuclear and optical principles have been described in detail [5] Thermalized neutrons incident on the glass fibers induce a $^{6}Li(n,\alpha)^{3}H$ reaction with 4 7 MeV of exothermic energy mostly carried by the ^{3}H The alpha particle and triton interact with the glass matrix to produce ionization When the ionization transfer energy to a Ce^{3+} ion, the emission of optical photons (400nm) occurs during the return to ground state Fluorescence lifetime is about 40-60 ns, therefore high-speed electronics can be used to advantage with shorter deadtimes and correspondingly higher throughputs (>10 Mcps) than possible with ^{3}He tubes (deadtime $\approx$ 1 μs)

The Ce / ^{6}Li bearing silicate glass composition is reported to be the best candidate for these waveguides [6] A hot-downdraw process in an anoxic environment is employed to manufacture the fibers Fibers, from 1cm to 2m in length are bound with RTV in bi-layer ribbons and layered with a hydrogenous moderator The ends of the fiber bundles are optically coupled to two or more PMTs and their outputs are processed to determine both the pulse-height of the event and whether the event results in signals at two or more of the PMTs within a set time domain

Neutrons deposit all of their energy in a single fiber resulting in light output at both ends of the fiber The glass is sensitive to gamma rays that interact by photoelectric absorption, Compton interactions and pair production due to the higher effective Z of the silicate glass relative to gas tubes This sensitivity can be both an advantage or disadvantage depending on the application For neutron assay applications including passive, active and multiplicity, the glass sensors may not provide either technical nor price advantage over conventional ^{3}He or BF_3 tubes Even with the excellent neutron to gamma discrimination, the spillover from the neutron to gamma channel adds unwanted variance and hence greater inaccuracy for assay applications The cost of the additional PMTs adds to the overall price of such systems On the other hand, for surveillance or detection applications where total neutron counting provides enhanced sensitivity, the glass performs better and at lower cost than comparable gas sensors Furthermore, the gamma sensitivity is useful because a shielded source of Pu will result in the hydrogenous material may partially shield the neutrons, but they also interact to yield H capture gamma rays of 2 2MeV Hence, a lower neutron count in conjunction with a gamma count is an indication of a shielded Pu source

Gamma-rays interacting in the glass that create photoelectrons and Compton electrons produce a much smaller pulse than neutrons because the electron's range is greater than the 120-mm diameter of the fibers The resulting energy is deposited in multiple fibers compared to neutrons that deposit their energy in a single fiber The light output of both the neutrons and gamma rays is small and must also be discriminated against any dark noise in the individual PMTs Through pulse-height discrimination, neutron to gamma discrimination ratios from 1000 1 to over 8500 1 have been achieved These discrimination ratios minimize the problem of gamma sensitivity for neutron assay For surveillance applications, this sensitivity can benefit the measurement objective The PMTs used in past applications have shown both temporal and temperature insensitivity The scintillating fiber sensors have performed well in field applications and have been space qualified Their principle technical advantage over ^{3}He tubes is the added active area that provides improved sensitivity

3 Applications

Panels from 0 5m^2 to 5m^2 can be fabricated for stationary and portable applications Examples include panels for portal monitors, soil monitors, freight monitors, truck and railway car monitors A 2m^2 roadbed monitor can measure 10g of weapons grade Pu in 10 seconds at a source to detector distance of 1m A Pu storage container monitor has been constructed consisting of eight 3 5cm-wide bi-layer ribbons that encircle the container Encircling the container with ^{3}He tubes would cost many times more than the glass fiber sensor An extended duration measurement resulted in less than a 3% increase in the neutron channel when 1 8mCi ^{60}Co or 9 5mCi ^{137}Cs source was added to the PuO_2 in the container [7] Using the criteria $\check{S} = 1\text{-}S/S_{avg}$ provided five identified alarms over a 45 day period Each alarm was correlated with human activity near the container or other factors Low-power electronics allow small concealable devices and sensors such as vests for weapons verification The conformable ribbons are perfectly suited for Pu lung measurements using direct neutron observation rather than relying on the low-intensity gamma rays or low-energy L X-rays Although the sensors can be flexible, the conformable packaging can be constructed in a fixed geometry to provide a reproducible source to detector geometry Current product development also includes hand-held devices for lower sensitivity but highly portable customs applications

The electronics package for these products include the complete analog and coincidence circuits coupled to a microprocessor with local readout and remote data transmission capability Data taken over present intervals are stored in a 64k non-volatile buffer until transmitted to a central PC or local data logger Background and efficiency data are stored for both neutrons and gammas to provide output in units of net counts per second or mass of Pu Alarm set points trigger the unit to provide local or remote visible, audible or tactile alarms

4 Conclusions

These sensors are better suited and provide superior performance to ^3He gas detectors for certain safeguards monitoring and surveillance applications requiring lightweight, large-area sensors They are also well-suited for small concealable sensors and field applications that are rugged or require unusual form factors

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RADIATION DETECTION TECHNOLOGY ASSESSMENT PROGRAM (RADTAP)

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Abstract

The U.S. Customs Service and the U. S. Department of Energy (DOE) conducted a technical and operational assessment of gamma ray radiation detection equipment during the period May 5-16, 1997 at a testing facility in North Carolina. The effort was entitled, "Radiation Detection Technology Assessment Program (RADTAP)," and was conducted for the purpose of assessing the applicability, sensitivity and robustness of a diverse suite of gamma ray detection and identification equipment for possible use by Customs and other law enforcement agencies. Thirteen companies entered 25 instruments into the assessment program All detection equipment entered had to exhibit a minimum sensitivity of 20 micro-R per hour (background included) from a Cesium-137 point source. Isotope identifying spectrometers entered were man-portable and operable at room temperature with read-out that could be interpreted by non-technical personnel. Radioactive sources used in the assessment included special nuclear material, industrial and health isotopes. Evaluators included Customs inspectors and technical experts from DOE and Customs. No conclusions or recommendations were issued based on the quantitative and qualitative test results, however, the results of the program provided law enforcement agencies with the necessary data to select equipment that best meets their operational needs and budgets.

1. Introduction

The proliferation of nuclear materials available for illicit transfer and sale is a national security concern for the U.S. Among the many border missions of the United States Customs Service (USCS) is the prevention of illicit import or export of nuclear materials (or any radiation-emitting materials that may pose a public health hazard) through U.S. ports of entry. The detection and identification of such materials requires state-of-the-art equipment and trained personnel to effectively counter these threats.

1.1. Background

The USCS operates at more than 300 land, sea and air ports of entry. Approximately 6000 inspectors enforce 400 laws for more than 40 U.S. government agencies. The highest priority, highest profile mission of Customs is the detection and interdiction of drugs. Traffic volumes at the borders are immense. For example; in 1997, border entry crossings: Land--365 million (M) pedestrians; 118 M cars, 6 M tractor-trailers; Sea--8 M passengers, 214 thousand (K) boats, 5 M containers; Air--68 M passengers, 706 K commercial airliners, 130 K private planes. Based on multiple border responsibilities, priorities, and massive border crossing volume, USCS has determined that introduction of radiation detection instrumentation would have to be non-interfering with normal operations, exhibit near real time response, and require minimum technical challenge for inspectors. These requirements greatly influence the equipment to be selected for the detection and identification of radiation sources.

A plethora of radiation detection devices from scores of vendors were known to be available on the open market or under development world-wide. The means to verify objectively, product specifications and vendor representations of their products' capabilities, was lacking. Further, most of the available equipment had not been put to the test in operational environments that approximated real conditions to determine their true utility from a non-technical operator's viewpoint. The need for a comprehensive assessment program was thereby established.

1.2. Purpose

The purpose of RADTAP was to assess the capability, sensitivity and robustness of gamma radiation detection equipment. These assessments evaluated both commercially available and field prototype nuclear radiation detection and identification instruments under laboratory and field simulation scenarios. RADTAP results were to provide unbiased information for use by federal, state, and local law enforcement agencies. Individual test reports, describing the appraised performance of each evaluated instrument system were distributed only to the specific system manufacturers. Reports of all manufac-turers' performance were made available to appropriate enforcement agencies, on a "Government Use Only" basis. Explicit conclusions, recommendations, and rankings were not made regarding the equipment accomplishments. The anticipated utility of RADTAP is to allow agencies to examine the compatibility of the equipment performance with their requirements, applications, detection strategy, and budget.

1.3. Objectives

The objectives of RADTAP were two-fold: (1) to evaluate quantitatively the detection performance of gamma ray radiation detection and identification equipment entered into the assessment program and (2). to provide qualitative information on normal operational aspects of the systems in USCS-specific operational scenarios. The specific detail relating to the satisfaction of these objectives is discussed in Paragraphs 2 and 3 below.

1.4. Equipment Assessed

USCS published an announcement in the Commerce Business Daily [the U.S. government's formal advertising means to solicit vendor/developer participation in procurements], soliciting participation in RADTAP during the period May 5-16, 1997. The specific categories of detection/identification equipment requested and the number of instruments selected and entered into the Program included:

(a) Personnel-worn (pager-type, fanny pack, etc.)--seven systems assessed.
(b) Hand-held--eight systems assessed.
(c) Man portable (backpack)--no submissions for this category.
(d) Small portal system--eight systems assessed
(e) Spectrometer-based system--five systems assessed

Two of the instruments were assessed under two categories, i.e., one hand-held system and one portal system also had spectral analysis capabilities.

2. Quantitative evaluation

2.1. Bench Tests

Two controlled bench tests were developed and conducted for detection equipment to verify the minimum sensitivity and to measure the detection sensitivity (maximum distance to a target response) to a number of radiation sources over a range of energy levels (60 KeV - 2.6 MeV). Tests were conducted in an enclosed structure with background measured at 10-12 microR/hr.

2.1.1. Minimum Sensitivity Verification

For participation in RADTAP a minimum sensitivity requirement of 20 microR/hr (background included) from a Cesium 137 source was required of all detection instruments. Three instruments, all personnel-worn dosimeters, failed the minimum sensitivity requirement and were disqualified from further participation in RADTAP. Dosimeters require time to accumulate counts that exceed a threshold dose rate and then produce an alarm. They were not intended as primary detection/alarm instruments.

2.1.2. Target Response

For the personnel-worn and hand-held instruments that passed minimum sensitivity verification, additional measurements were taken to determine sensitivity to a sequence of gamma ray radiation sources. Each instrument under evaluation was placed in a fixed location. In turn, each of several radiation sources was placed directly in front of the detection instrument, causing the instrument to alarm. The radiation source was then moved away from the detector to the point that the alarm stopped, i.e. the point that the detection threshold was reached). The distance was recorded, along with readings from a calibrated health physics instrument. Table I is an example of the results obtained for one of the personnel worn detectors.

2.2. Detection Performance Assessment

A series of scenarios simulating realistic USCS operational environments were developed and configured to assess the capability of each instrument to detect and locate radiation sources in a "field" setting. DOE personnel, serving in the capacity of evaluation controllers, randomly emplaced radiation sources in various locations typical to the corresponding scenario (e.g., baggage, cargo containers, parcels/packages, and vehicles). The operational scenarios (which simulated typical Customs environments) used to assess the performance of the various classes of detector are shown in Table II. For each scenario, the USCS inspectors readied and deployed the appropriate detection instrument, conducted an inspection using standardized procedures, and recorded inspection events. Inspectors did not have prior knowledge of the type or placement of the target radiation sources. An example of the data generated from these scenario-based assessments is depicted in Table III for one of the hand-held detectors entered into the program.

2.3. Spectrometer Performance Assessment

The inclusion of room temperature, gamma ray spectrometers in RADTAP was intended to identify instruments that provide accurate isotopic analysis in simple, non-technical terms for USCS and other law enforcement personnel. The spectrometer should be capable of identifying isotopes within the general categories of special nuclear material (SNM), medical, industrial, elevated potassium (^{40}K), or background radiation. Employment of a spectrometer would usually coincide with an alarm from a gross gamma count instrument when the results could not be resolved through normal procedures. Upon detection and approximate localization of a radioactive source, the suspect item would be directed to a secondary inspection area or secured in place. Thus, the spectrometer is used as a second step for further inspection and analysis of a suspect item.

Using the source emplacements configured for the detection performance scenarios, the above procedure was simulated and individual spectrometers were assessed. The instruments were readied and deployed by the inspector, the detector element was placed as close as possible to the approximate location of the source (i.e. on contact with the vehicle, shipping container, luggage item, etc.) to obtain an optimum measurement, and the analysis results were recorded.

3. Qualitative evaluation

The qualitative assessment was designed to obtain data from non-technical personnel (i.e., USCS inspectors) relative to the physical attributes and usefulness of assessed equipment in a USCS operational environment. Although somewhat subjective, the inspectors conferred after use of each instrument and provided collaborative ratings and comments within the context of the operational scenario being conducted. Each of the following criteria was rated using a numeric scale of 1 through 5, with 1 being least favorable and 5 being most favorable:

(a) Display characteristics and ease of interpretation (readability and understandability)
(b) Utility and clarity of user controls (ease of use, understandability, robustness)
(c) Handling (weight, portability, handle and sensor placement).
(d) Alarm enunciation (audible, visual, response time)
(e) Ease of battery replacement
(f) Overall usefulness in a USCS environment

4. ASSESSMENT RESULTS

Results of this assessment are documented in a 150 page document entitled, "Radiation Detection Technology Assessment Program (RADTAP)." The report is intended solely as a reference document for govenment agencies and contains no explicit recommendations with respect to the assessment results. Data contained therein are considered proprietary with distribution for "Government Use Only," at the discretion of USCS, Applied Technology Division, 1300 Pennsylvania Avenue, Washington, D.C. 20229.

Table I
Personnel Worn Detector--Target Response
(The maximum distance at which the instrument alarms for specific isotopes)

Source	^{241}Am	^{57}Co	^{133}Ba	^{137}Cs	^{88}Y	^{232}Th	^{131}I	LEU	HEU	^{239}Pu
Radioactivity	50μCi	212μCi	195μCi	68.2μCi	170μCi	59.7μCi	104.7μCi	2.2mCi	590μCi	63 mCi
Distance	83 in	283 in	232 in	79 in	227 in	26 in	53 in	49 in	149 in	466 in

Table II
Detection Performance Assessment
Hand-held Detector

Scenario	Source (radioactivity)	Container	Source Strength (in container)	Source Placement	Source Strength (where placed)	Detect?
Land Border, Veh Walk-By	I-131 (104.7 μCi)	Bag S16	5 mR/h contact, 125μR/h @ 1m.	White Chev Celebrity, front ctr of trunk	200 μR/h contact, 18μR/h @ 1m.	Yes
	U-235 (2.2 mCi) LEU, 4.3% enrch	Bag S18	120 μR/h cntct, 24 μR/h @ 1m	Red Corsica, rear seat, driver's side	100 μR/h contact, 18 μR/h @ 1 m.	Yes

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RADIATION PAGER

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Abstract

Methods of interdicting nuclear materials to date have favored the use of large portal detectors at choke points, or hand carried instruments used by trained personnel for conducting spot searches. Although these methods are effective in some instances, it is often impractical to insert choke points at busy traffic areas, and it is not cost effective to maintain a force of skilled operators whose focus is nuclear interdiction.

Recent technology developments are causing profound changes in the philosophy and methods employed for interdicting nuclear materials. Breakthrough advances in the miniaturization of detectors and low power electronics have made possible a new class of small gamma-ray radiation detectors, roughly the size of a message pager, with unprecedented sensitivity for their size. These instruments, named Radiation Pagers™, are ideally suited for use by untrained individual law enforcement personnel and emergency responders in the course of their regular duties.

New tactics that utilize a radiation detector worn by every officer are creating a moving curtain of detection with a significantly higher likelihood of locating illicit nuclear contraband. These individual detectors also provide each officer with a high level of confidence that they are not being unknowingly irradiated in the course of their work.

1. SEARCHING FOR RADIOACTIVE CONTRABAND

Until recently, commercially available equipment was either not sufficiently sensitive or was impractical to carry and use. As a result, most of the interceptions of smuggled nuclear materials to date have been a result primarily of good investigative work, rather than through the use of radiation detection devices. To be effective, an instrument must operate in a hands-free manner, be simple to operate, be very reliable, have a detection time (integration time) of less than one second with a low false alarm rate, have an affordable cost for acquisition and maintenance, and be available in large numbers.

Although nuclear materials emit both gamma rays and x-rays, so do many naturally occurring materials. There is a radiation background everywhere that is caused by trace amounts of naturally occurring radioactive elements in soil and building materials. There is also a radioactive contribution from cosmic rays, which becomes more significant with altitude. In addition, radioactive decay of uranium in the soil produces radon gas, which can increase the natural background radiation depending on weather conditions. All of these contributors combine to produce the low level radioactive background against which illicit nuclear materials must be detected.

There are also a number of common radioactive sources encountered by all of us on a day to day basis. Many objects contain small quantities of natural thorium or uranium. Examples include some camera lenses, welding rods, and lantern mantles. Antique glass sometimes contains uranium as a coloring agent, and some dishes produced in recent years utilize uranium glaze. Natural marble objects, such as statues, tiles, and architectural pieces, often contain high concentrations of uranium and thorium, and can be considerably more radioactive than their surroundings.

By far the most common radioactive source likely to be encountered in public areas are out-patients that have received medical uptakes. Approximately 5 million patients each year receive nuclear medicine therapy and diagnostics in the U.S., and although the radioactive agents used generally have short half-lives, many individuals can remain detectable for days or weeks. Among the traveling public, it has been observed that approximately one in 30,000 people are detectable from nuclear medicine uptakes.

Once a suspicious radioactive emitter has been detected and localized, identification and threat determination is often a matter of common sense and the process of elimination. In other cases, however, it may be necessary to bring in specialized equipment to obtain gamma-ray spectral, or energy information for diagnostic analysis by experts.

The most critical need, however, is for early detection. The capability to do this has recently been dramatically improved by commercially available small, highly sensitive, belt worn radiation detectors.

2. One man-one detector

One result of this new technology is the practicality of each individual officer possessing a sensitive personal radiation detector, much as each officer now possesses a weapon or a radio. These instruments are relatively inexpensive, are small enough to be worn on the uniform, and are low powered enough that they need not be turned off.

A major advantage of many small radiation detectors is their inherently closer distance to the radiation source. Because the intensity of radiation from a source varies with the inverse square of its distance, detector size must increase by a factor of four to merely double detection distance. The upshot is that large detectors capable of sensing radioactive materials at farther distances are not mobile, and must be located at carefully selected choke points.

Many small radiation detectors, worn by many law enforcement personnel in the course of their regular duties, can represent a moving curtain of detection that can be far more likely to locate contraband nuclear materials. Once nuclear materials are detected, it is much easier to specifically locate the source with a small, hand-held detector, particularly in a dynamic environment. In addition, the economics of many small, distributed detectors can be very attractive compared to the cost of an expensive fixed-site installation.

3. The radiation pager

Message pagers have been used as the paradigm for the new class of miniature gamma-ray radiation detectors, which have been named Radiation Pagers ™. Like a message pager, the Radiation Pager is intended to be used by a single individual who clips it to their clothing or uniform and carries it on a routine basis. When radioactivity is detected above a pre-set background, the Radiation Pager notifies the owner by beeping or vibrating, similar to a message pager. When a button on the Radiation Pager is pressed, it provides a number between 0 and 9 indicating the level of radioactivity detected, analogous to the numeric display on a message pager. Most people quickly acquire an intuitive feel for the instrument and assimilate it into their normal working routine.

Although other small radiation detectors have been available previously, they have lacked a reliable, cost effective gamma ray sensor with sufficient sensitivity to have an integration time of less than one second with a low false alarm rate. These previous detectors have utilized either a peanut sized Geiger-Muller (GM) tube or a few cubic millimeters of a solid-state material. These work well for larger radiation sources that might pose a potential health hazard (and are an excellent choice for health physics applications), but they are inadequate for detecting weak radiation fields, as their count rate is not high enough to be statistically significant over the natural background radiation in a short integration time.

More sensitive detection devices are scintillators. Scintillators are essentially down-converters that absorb gamma rays and re-emit light at optical wavelengths. A number of inorganic crystals exhibit this property, as well as some organic plastics. There are trade-offs associated with the use of different scintillators, but in general they owe their sensitivity to their being dense solid materials.

The difficulty with using scintillators is in detecting the tiny amounts of light that they emit. Although solid state devices such as silicon photo diodes have been used with scintillators, these light detectors are severely limited in their performance by their noise and temperature characteristics. Photon multiplication device, such as photomultiplier tubes, have been the favored technology for use with scintillators, however these devices have been large and fragile in the past, making their use in portable equipment difficult. Recent significant breakthroughs in the miniaturization of photomultiplier tubes have made small, rugged, highly sensitive scintillation detectors possible.

Crystalline Cesium Iodide (CsI) has been chosen as the scintillation material for the Radiation Pager because of its high density, optimal light wavelength output, and rugged mechanical properties. This allows the Radiation Pager to survive the rigors of everyday real world use, such as drops, extremes in temperature, and fast temperature gradients.

The detector for the Radiation Pager is comprised of a CsI crystal 1.3 cm diameter x 3.8 cm long, which is coupled to a miniature photomultiplier tube. This is the largest possible crystal that can still fit into the pager sized plastic case of the instrument. These detectors have a typical sensitivity for the 137Cs 662 KeV gamma ray of 2.1 cps/microR/hr. By comparison, a GM tube of similar size has a typical sensitivity of 0.02 cps/microR/hr , and a 1 inch diameter x 1 inch long NaI scintillator such as might be found in a "lunch box" sized detector has a typical sensitivity of 2.9 cps/ microR/hr.

Independent test results for the Radiation Pager detection response as a function of various nuclear materials is shown in Table 1.

It is important to appreciate, however, that detector response is not instrument response, as integration time (response time) and false alarm rate must be considered. The Radiation Pager will detect 37 KBq of 137Cs with a 1 sec exposure at 10 cm with a false alarm rate of less than 1 alarm/day in a natural background of 0.1 [Sv/Hr.

The other enabling technology for the Radiation Pager is the recent availability of low power 3 volt integrated circuit devices in surface mount packages. As a result, the Radiation Pager has achieved an unprecedented continuous operational lifetime of over one year on a single pair of AA alkaline batteries. In routine use, the Radiation Pager, like a message pager does not need to be turned off.

The Radiation Pager has several other features that make it well suited for routine use by law enforcement agencies and emergency responders. The instrument has been designed to operate accurately at temperatures from -15 degrees C to +50 degree C (+5 degrees F to +122 degrees F). The instrument is resilient enough take the rigors of active operational use, and has proven in tests to be tough enough to withstand a three foot drop onto concrete. The Radiation Pager maintains it accuracy over a wide range of radiation fields, and has been designed it to be virtually impervious to latch-up in high radiation fields. The instrument has also been shown in tests to be impervious to EMI from a 5 watt radio transmitter directly adjacent to the case.

4. Conclusions

In the past the high cost, large size, and necessity for operator training has prevented the large scale use of radiation detectors for nuclear interdiction. That is changing. A new tool for the detection of radioactive materials, the Radiation Pager™, is now available as a result of recent advances in technology. The introduction of these new instruments, and the concept and tactics of One man-One detector, is rapidly improving the outlook for nuclear interdiction.

Table 1 - Maximum distance at which the instrument alarms for specific isotopes. Data taken from tests by the Radiation Detection Technology Assessment Program (RADTAP), jointly conducted by the US Customs Service and the US Dept. of Energy, May 5-16, 1997

Source	Radioactivity	Distance
^{241}Am	50 [Ci	83 in
^{57}Co	212 [Ci	283 in
^{133}Ba	195 [Ci	232 in
^{137}Cs	68.2 [Ci	79 in
^{88}Y	170 [Ci	227 in
^{232}Th	59.7 [Ci	26 in
^{131}I	104.7 [Ci	253 in
LEU	2.2 [Ci	49 in
HEU	590 [Ci	149 in
^{239}Pu	63 [Ci	466 in

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Regulatory Infrastructure and Laboratory Background for Responding to the Illicit Trafficking of Nuclear and Radioactive Materials in Hungary

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Abstract

The revealed cases prompted efforts to provide a comprehensive response to the illicit trafficking of nuclear and radioactive materials in Hungary. A governmental decree was issued on measures related to found or seized radioactive or nuclear materials, which regulates the response scenario, including the coordination of the competent authorities. The available laboratory background and technical resources were improved. Some limitations and technology gaps can be overcome by wider international cooperation.

1. Introduction

The appearance of illicit trafficking of nuclear material and other radioactive substances in Hungary in the last decade proved to be a serious challenge for our domestic regulatory and control system. Unauthorized receipt, provision, use, transfer or disposal of these materials poses a danger for public health and safety and – whenever nuclear material is involved – raises concern from the point of view of nuclear proliferation. The revealed cases prompted efforts to provide a comprehensive response including wider international cooperation, new legal instruments and improved technical resources.

2. Regulatory infrastructure

Hungary has a sound national control system for nuclear and radioactive materials. This includes state system for accounting and control of both, physical protection regulations, export-import control, regulation of transport and packaging, and radiation protection regulations in accordance with the international standards.

As an additional tool – in order to strengthen our national regulation and control system and to improve the efficiency of combating illicit trafficking - a governmental decree was issued on measures related to found or seized radioactive or nuclear materials in 1996. It defines the adequate operating procedures and priorities.

The primary purpose of the response is to bring the situation under appropriate radiation control by implementing radiation protection procedures. As a first step - if it can be assumed that an object is a radioactive or nuclear material - the police, competent border police or customs authority body has to prevent approaching the area and to notify the Main Duty Office of National Police Headquarters (MDONPH) without delay.

In addition to notifying its own responsible units, the MDONPH reports the incident to the duty offices of the following organs

(a) the Ministry of Public Welfare (in order to have a health physics expert dispatched to the spot)
(b) the National Security Office (NSO) of the Republic of Hungary

(c) the Hungarian Atomic Energy Authority (HAEA)
(d) the National Headquarters of the Hungarian Border Guard (in case of incident near the border or at a border crossing point)
(e) the National Headquarters of the National Board of Customs and Excise (in case of incident including materials or customs goods entering from abroad).

The health physics expert has to be informed on the spot about the measures taken and the conditions required for him to conduct his work have to be ensured. If he determines that the material is radioactive, he has to

(a) take a preliminary inventory of the material
(b) inspect the packaging, and have the materials collected if necessary
(c) decide on the method of transporting the materials, based on the preliminary radiation protection measurements
(d) keep a record of the facts he establishes and the measures he orders.

If the material can be transported by car, it shall be taken to the "Frederic Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene (NRIRR) to the storage site designated for this purpose. If the material cannot be transported in this way the health physics expert has to contact the Institute of Isotopes and Surface Chemistry (IISC) of Chemical Research Center of the Hungarian Academy of Sciences, which has to transport the material to its own site as soon as possible. He has to determine the radiological safety and other conditions for the transportation of the material from the site to the storage area. If it is considered necessary, these conditions (packaging, licensing, labeling, shipping papers) may diverge from the provisions set forth in the Appendices "A" and "B" of the European Agreement Concerning the International Carriage of Dangerous Materials by Road and the domestic application of such. This derogation cannot be applied for further transportation of the material at a later time.

NRIRR - on the basis of the tests it carries out – has to provide the health physics expert opinion required for the various procedures. If the material proves to be nuclear material the NRIRR have to inform immediately the IISC and has to agree on the applicable measurement methods. Following the completion of the health physics analyses, IISC has to transport the material to its own site. If the material was transported directly to the IISC site, IISC has to agree with NRIRR on the applicable health physics analyses methods. In order to fulfill the accounting and control obligations for nuclear materials, IISC has to conduct tests on the nuclear material. NRIRR and IISC have to inform the police, the NSO and HAEA regarding the results of analyses.

If the material is serving as forensic evidence, the regulations governing the handling and recording of objects seized in criminal proceedings shall be observed when taking samples of the material, as well as during the testing and storing of such.

In the interest of promoting international cooperation in relation to the illegal trafficking of such materials, HAEA provides data for the databank established by the IAEA.

In case of nuclear materials HAEA - on the basis of the IISC report - sends a report on the material to IAEA.

3. Technical resources

The results of the analyses – in addition to the health physics considerations – serve forensics as well. This imposes special restrictions and requirements concerning the applicable analytical approaches and equipment.

After transportation more detailed studies are performed on the materials using different approaches at the NRIRR. However, the first step is usually removing of shielding or even disguising materials around the radiation source in order to localize the radioactive materials. During this process the radiation dose rate and surface contamination are measured and the main components of radiation (i.e. alpha, beta, gamma, neutron) are examined, too.

Following the definition of the real position of the radioactive (or nuclear) material the type and activity level of the source is to be defined. This test strongly depends on whether the source is sealed or unsealed. If the radioactive material is a sealed source, then analysis is carried out mainly by non-destructive methods. In case of gamma emitting radioactive and even nuclear materials (e.g. uranium fuel pellets) the analysis can be easily performed by gamma spectrometry. In the latter cases the gamma spectrometric investigation needs a special efficiency calibration for the system, as the matrix is completely different from the matrices used for analysis of conventional samples.

In the more problematic cases when the materials are pure beta emitting sealed sources, the maximum beta energy has to be defined for the identification of the radioisotope, firstly. Then a relative intensity measurement is carried out with the same type of sample with known activity to calculate the activity level. Finally, the conclusion could be drawn that the activity level of the radioactive materials is higher than the exempted value, because this fact is the evidence for the criminal procedure.

In case of unsealed sources, or in more complicated situations alpha spectrometric and liquid scintillation investigations are also used following the chemical separation and appropriate preparation of the sample geometry.

Hungary has a nuclear power plant, but we have neither fuel fabrication nor reprocessing facilities. As a consequence we do not have the related destructive assay technologies for nuclear materials.

In the IISC the analyses of the nuclear material is performed by non-destructive assay (NDA) methods based on high-resolution gamma spectroscopy.

Intrinsic calibration method is applied to determine the isotopic abundance of the nuclear material. The evaluated region of the gamma spectrum depends on the thickness of the cladding of the material. Whenever it is possible, the gamma lines in the 90-210 keV region are used. For this measurements application of a high purity germanium planar detector is preferred. If absorption in the cladding is too strong the analyzed region is extended up to 1001 keV, and the measurement is performed by high purity germanium coaxial detectors.

The element concentration is determined by absorption ratio correction method (ARCM). The absorption in the cladding and the matrix and the self-absorption in the nuclear material are determined from intensity ratios of different gamma lines. The total amount of the nuclear material is determined – following the absorption corrections - by the measurement of the intensity of a gamma line. For uranium they are the 186 keV line of ^{235}U or the 1001 keV line of ^{234m}Pa.

Destructive assay (e.g. mass spectrometry) of the material would serve the source attribution, but the databases – required for the reliable interpretation of the analytical results – cannot be accessed for the time being.

4. Conclusions

A sound framework was established for responding to the illicit trafficking of nuclear and radioactive materials in Hungary. A governmental decree was issued on measures related to found or seized radioactive or nuclear materials, which regulates the response scenario, including the coordination of the competent authorities. The available technical resources were improved although some limitations and technology gaps – originating from the character of the nuclear technology of Hungary – remained. These problems can be overcome by wider international cooperation.

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COMBATING ILLEGAL NUCLEAR TRAFFIC - POLAND'S EXPERIENCE

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Abstract

International non-proliferation efforts have been taken to reduce the risk related to nuclear materials and radioactive sources. The physical security of nuclear facilities to prevent acts of sabotage or terrorism and to protect nuclear materials against loss or seizure is an essential element of the nuclear non-proliferation regime. Iraq case and the end of the Cold War have influenced the development of co-operation and openness in many countries.
Poland due to:
- *its geolocation,*
- *a growing number of post Chernobyl contamination transports and*
- *high risk to become a transit country in illicit trafficking of nuclear materials and radioactive sources,*

initiated deployment of the fixed installation instruments at the border check-points.
Since the end of 1990 to now 103 such devices have been installed. Broader involvement in combating illicit nuclear trafficking of Border Guards, Customs Services, Police and Intelligence Security has been noticed.
Paper presents Poland's experience in implementing national prevention measures to reduce nuclear proliferation risk and in detecting capabilities against illicit nuclear traffic.

1. Introduction

Poland lies across important communication routes between East and West Europe and this might be exploited by a potential nuclear proliferator. The country itself has only modest nuclear activities, but using a high enriched uranium (HEU), as a fuel (enriched to 36% and 80% of U-235) for research reactors might pose proliferation risk if a proper security system is not provided.

Transition to democracy and market oriented economy began with the liberalization of foreign trade, particularly export enjoyed favourable treatment and that could present a threat not only to Poland's security but also to the West. In spite of nuclear materials and radioactive sources in peaceful nuclear activities being covered by Safeguards Agreement (concluded with the International Atomic Energy Agency /IAEA/ in 1972) and/or the national Atomic Law (the Act of Parliament of 1986), there was a proliferation danger of some nuclear materials or radioactive sources from the Soviet/Russian military bases still then deployed in Poland (the withdrawal of Russian troops was completed on 17 September 1993). Ignorance or lack of control of radioactive sources in those military facilities gave rise to losses (thefts)[1] and threats[2] to the environment or unsuspected individuals afterwards. Of particular concern

[1] In May 1995 police found container with two Cs-137 sources, of activity 52 mCi and 2.1 mCi, stolen in 1992 from the former Russian military base in Borne-Sulimowo. The seizure was in a private apartment in Koszalin.

[2] In August 1993 seven sources of Co-60, 1 mCi each, were found by the Security Service staff in a forest near Szczecin. The sources were of Soviet origin and very probably used in military base.

was the proliferation risk from the Former Soviet Union (FSU), because of the continuing ease of access to nuclear materials and nuclear weapons.

Additional nuclear related causes of illicit trafficking in Poland:

- post Chernobyl contamination transports of commodities,
- transfer of radioactive waste for their disposal or utilisation (the Law on Environmental Protection forbids the import of dangerous waste in Poland),
- transport of contaminated metal scrap.

2. National Control System

Poland has developed and implemented quite effective prevention system for combating illicit trafficking in nuclear material and radioactive sources.

National regulatory infrastructure on control of nuclear material and radioactive sources is founded upon two legal Acts of Parliament:

- The Atomic Law,
- The Law on Special Control of Foreign Trade in Goods and Technologies Subject to International Agreements and Obligations called also the Export/Import Control Law (1993).

The President of the National Atomic Energy Agency (NAEA) is responsible for issuing regulations on nuclear materials and radioactive sources.

The issued regulations, among others, include the following:

- The Principles of Accountancy and Control of Nuclear Materials (1987),
- The Principles for Keeping Records and Controlling Ionizing Radiation Sources (1987),
- The Terms and Conditions for the Export, Import and Transfer through the Territory of Poland of Nuclear Materials, Radioactive Sources and Equipment containing such Sources (1988 changed in 1997),
- The Principles to be followed in the Physical Protection of Nuclear Materials (1988).

Concerning the Export/Import Control Law, the Minister of Economy issues a list of goods and technologies subject to special control. The last modification of the list was on 31 December 1996 and its format is based on the European Union's control list. The list contains items crucial to the nuclear fuel cycle or to nuclear explosive devices, as internationally agreed and proposed by the Nuclear Suppliers Group (NSG):

Trigger List (INFCIRC/254/Rev.1/Part 1) and

Dual-use items (INFCIRC/254/Rev.1/Part 2).

The licensing and control tasks resulting from the Export/Import Control Law were entrusted to the Department of Export Control of the Ministry of Foreign Economic Relations (since 1 January 1997 - the Ministry of Economy). On questions related to nuclear materials, equipment, technologies and dual-use items important for nuclear fuel cycle, a licence of the NAEA is a precondition to the general export/import licence.

3. Detection Capabilities

The strengthening of prevention measures against illicit trafficking Poland combined with the enhancing of detection capabilities of the law enforcement bodies, especially Border Guards and Customs Services.

According to the Law on Border Guards (Act of Parliament of 1990) the officers of the Border Guards have the right to control, stop or deny the entry to Poland of radioactive and nuclear materials and waste at the border check-points.

In 1990 a decision on monitoring radiation at border check-points was taken to detect all attempts of imported commodities with raised radiation level. It was decided to equip all border check-points with indigenous fixed installation instruments. The instruments are operated by the Border Guards, but the cost of installation is covered by local administration authorities.

At present (as of 1998) there are 103 such devices deployed in Poland (47 at road check-points, 33 at railroad check-points, 13 at the airports and 10 in the harbours of the Baltic Sea) [1]. In practice they cover Polish Eastern border (with Ukraine, Belarus, Lithuania and Russia) and majority of the crossing points with other neighbouring countries.

The fixed installation instrument consists of [2]:

- a detection block, which contains large volume sodium iodide (NaI) (2.5" * 2.5") scintillation detector in a lead collimator,
- a computerized control panel,
- a signal panel (optical - acoustic).

The unit allows to detect 125 μCi (4.6 MBq) of gamma ray source Cs-137 within a distance of 5 m. from the detection block, when a vehicle is moving with a speed up to 30 km per hour. The alarm threshold can be set within the range from 1.7 μR/h to 31.8 μR/h [2] (or from 0.017 μSv/h to 0.318 μSv/h) above the background gamma dose rate.

In Poland's practice an alarm is activated when the measured gamma dose rate exceeds twice the background level. In 1997 out of 82 million vehicles passing the checking gates, some 15000 alarms had occurred and in 487 incoming transports of contaminated material the entry was denied (in 1996 - 640 transports were denied) [3] .

Stopped vehicle is moved out of control zone and examined thoroughly with hand-held instruments. Some 600 hand-held dosimeters and surface pollution meters (Polish origin) form the measuring capabilities of the Border Guards staff. Since June 1996 the Border Guards have in use a mobile unit equipped with the instrumentation for detection of arms, drugs and radioactive materials.
Activities of the Border Guards can be supported by customs officers, who are also equipped with hand-held instruments for detecting radiation, while checking luggage.

In dubious cases the border controlling staff seek advice or help with the prevention and emergency service team from the Central Laboratory for Radiological Protection (CLRP), which is responsible for providing help in case of accidents with radioactive and nuclear materials. The team is on duty around the clock and serves as a source of advice or first aid to Border Guards, Customs Services, Police, State Security Office or other law enforcement officials. If a phone advice is not sufficient the officer on duty arrives at place, where illicit event happened and he takes action in accordance with the requirements of nuclear safety and radiological protection. When circumstances require an immediate response a mobile laboratory with high resolution spectrometer can be utilized by the emergency team from the CLRP.

The number of actions taken by the Prevention and Emergency Center of the CLRP is diminishing, but amounts to 60 - 100 per year.

The emergency team elaborates report on each radiation event and notifies the regulatory authority, which is the National Atomic Energy Agency. Poland reports to the IAEA on illicit trafficking in nuclear material and radioactive sources detected at the borders or within the country.

The identification and analysis of radioactive sources and nuclear material seized at the border or within the territory of Poland has been carried out by the CLRP. At present the Laboratory has not capabilities to determine enrichment of HEU or Pu isotopes, but up to now there were no such needs, for among analysed unknown samples were radioactive substances, natural uranium, depleted uranium and low enriched uranium (LEU). The Laboratory applied alpha and gamma spectrometry for analysis of unknown radioactive substances and high resolution gamma-ray spectroscopy for uranium samples.

3. Summary

The legal foundations of Poland's prevention and control systems are perceived by international bodies involved in the strengthening of the global nuclear non-proliferation regime as conforming to international standards.

The borders of Poland could be recognised as well protected against illegal trafficking of radioactive materials. However, in case of any attempt of nuclear material smuggling the situation could become more complicated, for there are no instruments to detect HEU or Plutonium.

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DETECTION AND MONITORING SYSTEMS FOR THE PREVENTION OF ILLICIT TRAFFICKING OF RADIOACTIVE AND NUCLEAR MATERIALS AT SEA PORTS IN EU MEMBER STATES.[1]

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Abstract

Illicit trafficking of radioactive and nuclear materials at sea ports may be considered as a serious problem. For this reason, a feasibility study has been carried out in order to investigate the detection possibilities of nuclear materials hidden in cargo which is handled at sea ports. Special attention is given to cargo packed in and transported with freight containers.

Detection methods depend upon the measurement of gammas and neutrons, emitted by the nuclear material which is hidden. Detection limits of existing monitoring systems are unknown for geometrical configurations comparable to those specific at sea ports. For this reason calculations were carried out by means of the MCNP-4A Monte Carlo code in order to estimate these detection limits. These calculations are related to passive and active neutron assay, localised gamma sources and contaminated iron scrap.

Results of this study are that radioactive materials can be detected without major problems. Passive neutron assay allows the detection of nuclear material in relative small quantities of plutonium in the absence of any deliberate neutron shielding, whereas in the case of dense neutron shielding, detection limits of several kilos of plutonium are obtained.

A promising method appears to be a gamma- and neutron monitoring system in combination with an existing X-ray scan installation for cargo verification of container content. The detection probability is further increased when extra intelligence is applied about the origin and route of the cargo.

1. Introduction

Apart from explosives and drugs, the illicit trafficking of nuclear materials poses a problem, due to the risk of proliferation of nuclear materials. Political instability has demonstrated to be one of the main causes for cases of illicit trafficking in recent years. The illicit trafficking of radioactive materials also poses a problem for the health of the population and for damage to the environment. This can be "accidental" diversion or contraband of nuclear materials, non-shielded materials, and accidental contamination of scrap materials.

Being aware of this concern, DG XVII of the European Commission requested a feasibility study on detection and monitoring systems and procedures for the prevention of illicit trafficking of radioactive and nuclear materials. The effort has been concentrated upon sea ports of the European Union, for which possible detection techniques and systems are investigated.

[1] Task performed under CEC Contract 4.1020/D/96-007

In this paper detection and monitoring systems for the prevention of illicit trafficking of radioactive and nuclear materials are investigated from the technical point of view. In particular, performance characteristics (like sensitivity and detection limits) of detection systems are studied, limited to the specific case of container transport at sea ports. The monitor systems are capable to detect either gammas or neutrons originating from natural background. In case nuclear materials are approaching, an increase in signal takes place, that depends on the radiation level. Any measurement of neutrons and/or gammas above natural background is an indication for the presence of nuclear materials. Hence, the key question in the detection of smuggled materials is the significance of the signal increase above the natural background within the appropriate statistical treatment of the signal.

2. Characterisation of import flows in sea ports.

With respect to illicit trafficking of nuclear materials, several possibilities can be distinguished to bring these materials into ports of European Member States. However, successful illicit trafficking of nuclear materials requires an easy and reliable opportunity to retrieve these materials from the cargo. Cargoes satisfying these criterion are:

- cargo packed in freight containers (full container loads);
- conventional cargo, provided that the nuclear materials are hidden inside the cargo;
- certain cargoes carried with specialised vessels;
- trailers on Roll on-Roll off vessels.

In this paper, only attention is given to cargo packed in and transported with freight containers. This choice is supported by the current and fast growing volumes of this type of transport.

3. Techniques for detection and monitoring of nuclear and radioactive materials

Signatures of radioactive and nuclear materials consist of spontaneous and induced radiation, emitted by the materials under investigation. Radioactive materials are mostly gamma emitters but some are beta emitters and cannot be detected by gamma measurements. Nuclear materials can emit as well neutrons as gammas, and can undergo fission under external irradiation, resulting in the emission of extra neutrons and gammas. Radioactive materials can emit gammas but no neutrons. This means that if radioactive materials must be detected, the method should be sensitive to gamma rays.

Gamma-rays are sensitive to all gamma attenuating materials that can surround the source, such as container materials, but also provocatively installed shielding materials. This attenuation phenomenon is more effective for lower energies. Gammas originating from nuclear materials do have low energy and are therefore easily absorbed in materials of packing and container. The size of the container and the density of the materials also play a role for the attenuation process. However, quantification of the content is not considered as a first concern, but has only a second order priority. Therefore, integral detectors without any energy (and isotope) discrimination can be used.

Nuclear materials can also emit neutrons, apart from their gamma emission. In case of neutron detection, several kinds of neutrons can interfere: coincident neutrons from the spontaneous fission neutrons of the even isotopes (e.g. Pu or U); (I,n) neutrons of light elements (such as oxygen, fluorine); and neutrons induced by one of the previously mentioned neutrons (called multiplication).

Neutron detection can aim at detecting either fertile isotopes (e.g. the even isotopes of plutonium) or the fissile isotopes (e.g. the odd isotopes of plutonium). The technique applied, either passive or active, will determine the kind of isotope that will be addressed. A prevailing factor to make such a decision is the significance of the spontaneous and induced emission rates of a particular material. If an active technique is used as an interrogation of nuclear materials, source neutrons can contribute to the detected signal, and the technique has to include discrimination between neutrons from the radioactive material and source neutrons (e.g. by applying the Cf-shuffler and the differential die-away (DDA) technique). Various measurement techniques can be applied as given in Table I.

In addition to the detection methods which are based upon the radiation characteristics of the contraband, one can also take advantage of the physical properties. Nuclear material has an extreme high density and this would result in sharp contrasts on X-ray photographs.
Heimann Systems GmbH [2] has developed an X-ray technology for inspection of containers which is based upon a dual configuration of 2 linear accelerators. The X-ray scanning is performed in horizontal as well in vertical direction. Computer assisted image processing gives information of the content, such as volume, relative density and location of the objects inside a container.

able I: Analysis of detection methods

Material to be detected	NDA technique			
	gamma	neutron passive	neutron active	remarks/problems
Pu metal	all isotopes but Pu-242	fertile isotopes by: - total neutrons - coincident neutrons	fissile isotopes by: - total neutrons - coincident neutrons	low-energy gamma lines thermal neutron detection (isotopic composition?) (neutron discrimination?)
Pu oxide	all isotopes but Pu-242	fertile isotopes by: - total neutrons - coincident neutrons	fissile isotopes by: - total neutrons - coincident neutrons	(I,n) neutrons powder, pellets (neutron discrimination?)
U metal	all isotopes	U-238	U-235	U-235 gamma 185keV difficult n-detection
U oxide	all isotopes	fertile isotopes by: - total neutrons - coincident neutrons	fissile isotopes	powder, pellets HEU, LEU
Radioactive sources	all isotopes but beta emitters	not applicable	not applicable	density, packing Co-60, Cs-137

The containers are scanned with an X-ray beam of 5 to 10 MeV. The maximum penetration of these X-rays in steel is 340 mm and in water 2300 mm. The scan is taken when the truck with container is pulled at a speedof 0.4 $m.s^{-1}$ through the inspection tunnel. Nobody is present in this tunnel during scanning. For the detection of nuclear materials, the applied software techniques for building the scan images has to be adapted to the high density properties of the nuclear material.

4. Detector performances

In the evaluation of signals from any monitoring system, a comparison is made of a signal with a background intensity. An alarm decision is taken only when a monitoring measurement exceeds the expected background result by an amount (the alarm level) that will limit the chance for a statistical false alarm to less than one in a few thousand passages of a vehicle through an monitor.

A literature search was made to identify existing monitoring systems. Vehicle monitors were found to be an appropriate solution [1]. Table II gives an account of detection limits for Cs-137, Co-60 and Am-241 for commercial available plastic scintillator detectors.

In order to confirm the findings from the literature, additional calculations were carried out with the MCNP-4A Monte Carlo code to estimate these detection limits. Since this project concerns the detection of radioactive material as well as the detection of nuclear material, both neutron and photon transport calculations were performed. To estimate detection limits, a specific and representative geometry and shielding has been considered. A 20 ft container type 2200 (20'x8'x8.6'), placed 1 m above the ground-plane with three detectors located 0.5 m beside and above the container and one in the ground-plane, is adequate to represent a truck or a train wagon passing a portal monitor. Results are given in Table II.

Table II: Detection limits; the density refers to the shielding density of the contents of the container.

Practical cases of vehicle monitoring; vehicle speed 8 km/h, portal width 4-5 m	MCNP-4A calculations (see text); vehicle speed 8 km/h (=1s) and stoppage (=60s)
Cs-137 : 23 kBq (7 ng) - 673 kBq (0.2 Tg) Co-60 : 15 kBq (0.36 ng) - 265 kBq (6 ng) Am-241 : 470 kBq (4 Tg)	Pu-239 : 10g (1s) - 2g (60s) - density 0.0g/cc Pu-239 : 45g (1s) - 6g (60s) - density 0.1g/cc Pu-239 : 25500g (1s) - 3300g (60s) - density 0.4 g/cc Pu-239 : 241000g (1s) - 31200g (60s) - density 0.7 g/cc

In particular detection will be successful to discover "accidental" diversion or smuggle of nuclear materials, non-shielded materials, and contamination of scrap materials. In case of real contraband, and supposing sufficient intelligence and skills from the divertor, the packing of the material will be in a form to neutralise all emitted radiation, as well gamma as neutron, making any detection of materials difficult, if not impossible. Support of an X-ray system, taking advantage of the extreme high density of nuclear material, is required to discover possible density differences that could be related to concealment efforts.

5. Proposed monitor systems for containers

Analysis of the various systems and locations to install systems to prevent illicit trafficking of nuclear materials leads to the following:

The most suitable option for the detection of radioactive as well as nuclear material is a vehicle portal monitor, consisting of gamma and neutron detectors, built in the vertical columns and the bridge of the portal. This monitoring system should be used in combination with an X-ray scan installation for container content verification and installed in the tunnel, just after the entrance . The efficiency of the portal monitor depends upon the integral measuring time and the distance between the detector and the hidden source. In case of a dynamic measurement (truck is moving) the maximum distance between source and one of the detectors never exceeds 2 meter. The efficiency of existing portal monitors is based upon trucks driving at 8 km/hr (2 $m.s^{-1}$). This efficiency can be increased when the truck is passing at lower speed or even artificial pulled at 0.4 $m.s^{-1}$ along the portal monitor.

Information of the X-ray scan image, especially the presence of materials with high density, and the results from the radiation monitor can be combined with custom information about the cargo content. The proposed measuring system will take advantage of the low background radiation level in the building of the X-ray scan installation, and the presence of skilled personnel. Extra profit of a combined X-ray scanning device and a gamma and neutron monitor is the fact that one can make use of the same logistic infrastructure and of personnel who is familiar with radiation technology.

The detection probability would be further increased if extra intelligence is applied. With the results of a complete route and transport analysis a pre-selection can be taken into account for selective examination of suspicious cargoes. Application of this intelligence will restrict the number of inspection stations and will reduce cost.

6. Conclusions

A feasibility study has been performed on the detection and monitoring systems for prevention of illicit trafficking of radioactive and nuclear materials at sea ports in EU Member States. From this study the following major conclusions can be drawn up:

- Monitoring of freight containers is essential because this type of transport spans the largest amount of transported cargo.
- Passive neutron assay allows the detection of nuclear material in relative small quantities of plutonium in the absence of any deliberate neutron shielding, whereas in case of dense neutron shielding, detection limits of several kilograms are calculated.
- Complex active systems do not provide significant advantages over more simple passive systems.
- For the detection of uranium the use of an active system is imperative, as a passive system does not give any significant signal.
- A promising method of monitoring nuclear material seems to be a vehicle monitoring system equipped with high sensitive gamma and neutron detectors in combination with existing X-ray scan installations for verification of cargo densities in containers.
- The application of extra intelligence would increase the probability of making the right selection for containers to be checked on nuclear material.

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CONCEPT OF ASSISTANCE OF THE FEDERAL OFFICE FOR RADIATION PROTECTION WITH REGARD TO SERIOUS CASES OF PREVENTION OF NUCLEAR HAZARDS

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Abstract

For the defence against the threats through radioactive substances, a general concept is presently being elaborated under the overall control of the Federal Government. A number of competent organisations are involved in this, for example the Federal Office of Criminal Investigation, the Federal Armed Forces, and the Federal Office for Radiation Protection.

In Germany, the 16 Federal States are responsible for the prevention of nuclear hazards. In the case of hazards through radioactive material, experts from the competent radiation protection authorities are consulted. For serious cases of prevention of nuclear hazards (nuclear fuels, criticality, danger of dispersion), the Federal Office for Radiation Protection - a subordinate authority of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety responsible for radiation protection - was given order to elaborate a concept for assistance to those Federal States. This concept is presented in the following.

1. Introduction

The field of prevention of nuclear hazards ranges from illegal trade with radioactive test emitters up to the defence of nuclear fuels with the possibility to construct critical assemblies or the threatening by the purposeful distribution of airborne material which might enter the lungs. The latter means the serious cases of prevention of nuclear hazards. Since the expenditures for devices and personal to be trained would be inadequately high, the Federal Office for Radiation Protection (BfS) was given order to elaborate a corresponding concept to support the Federal States in case it becomes necessary. The concept includes the search for radioactive material, analysis, risk assessment, and also measures to stem the risk.

2. Stand-by Service

To guarantee that the Federal Office for Radiation Protection can be reached at any time, a 24-hour-stand-by service was established. According to each individual case, the person on call may assemble a task force at the Federal Office for Radiation Protection's places of office, which are distributed over the whole Federal Republic of Germany. The Federal Office for Radiation Protection is represented in Freiburg near the border of Switzerland, Munich, Hanau near Frankfurt, Salzgitter near Hannover, and Berlin.

3. Search for Radioactive Material

3.1 Search from the Air

To search radioactive material from the air, the Federal Office for Radiation Protection has available altogether four measuring systems which can be installed at helicopters. With these measuring systems, an area of 30 square kilometres per hour can be scanned at an altitude of 100 metres with a flying velocity of 100 km/h and a path distance of 300 metres. The detection limit is approximately 1 GBq for a Co-60 emitter.

3.2 Search team for gamma sources

For the search of gamma-emitting material, the Federal Office has altogether 30 handy devices at its disposal, with a detection limit of 100 nSv/h. The detectors can be transported by car or helicopter within four hours to each location within the Federal Republic of Germany. The introduction of the search team at the location does not require more than five minutes. A 30-person search team can scan approximately one square kilometre per hour.

3.3 Search for neutron sources from a vehicle

For this task, the Federal Office for Radiation Protection has 8 highly sensitive neutron detectors at its disposal at the Salzgitter site, which can be installed in a vehicle. Each detector consists of three He-3 counters which are installed in a polyethylene moderator of the dimensions 105x27x10 cm^3. With this vehicle, fronts of houses or convoys can be scanned. Several 100 grames of unshielded reactor plutonium can be detected with this assembly from a distance of several metres, the search velocity being 10 km/h.

3.4 Concealed search for gamma sources

The devices mentioned in 3.2 are also suitable for concealed search. For this, the devices are equipped with an acoustic signal. The measuring instruments can be carried in a coat pocket. The signal can be heard over an ear clip. In contrast to 3.2, personnel especially trained for this kind of search is required, which would be provided by Federal Office for Radiation Protection in such a case.

4. Analyses of radioactive Substances

4.1 Determination of the Dose Rate

To determine the dose rate by gamma radiation, appropriate state-of-the-art measuring instruments are available at all BfS sites, the measuring range of which is between 10 nSv/h and 10 Sv/h. Part of these instruments is equipped with teleprobes, to be able to measure also hard accessible locations, like tubes, wells, treeholes.

To determine the neutron dose rate, six portable measuring instruments are available, so-called remcounters. The detection limits of these instruments start at 100 nSv/h - 1 µSv/h.

4.2 Nuclide Determination through Gamma Spectroscopy

Some instruments on the basis of germanium detectors are available for this important task. For nuclide determination in the field of nuclear fuels, these detectors must be particularly sensitive in the range of energy up to approximately 500 keV. The instrument most appropriate for this task is the so-called U-Pu-inspector of Canberra company which is also equipped with the special software required. This instrument can be used within six hours at every location in Germany.

4.3 Activity Determination

If the nuclide is known, an activity determination can be carried out with the help of the dose rate, unless there are external shieldings and the self-shielding can be neglected. If the geometry and the physical state of the substance can be recognised by X-rays, the self-shielding effect can be taken into account too. In particular in the case of plutonium, the activity can be estimated for standard geometries due to the use of the available neutron measurement technique with modules (see 3.3).

5. Risk Determination

The risk of an IED (Improvised Explosive Device) primarily consists of two components, the risk of the deactivator through the dose rate as well as in the nearer vicinity through the possible inhalation of radioactive particles after an explosion. The dose rate for gamma radiation and also for neutrons can be measured and the risk for the deactivator can be estimated easily.

To determine the risk by dispersion of the radioactive substances with following radiation exposure through inhalation of the particles by persons of the general population, the following parameters must be known: nuclide composition, activity, inhalation dose relevant portion, spreading in the atmosphere. With the help of these quantities as well as the known breath rate and the dose factor, the potential radiation exposure can be calculated.

For this purpose, the Federal Office for Radiation Protection drafted a concept for a first assessment for 12 relevant radioactive nuclides with plausible assumptions, which can be used by the measuring team in situ. The team has then to determine the deviations and, following this, to assess the radiation exposure from the given values with a correcting factor. Additionally, the determination of radiation exposure can be verified simultaneously with the help of a computer programme.

6. The concept for avoiding the release of radioactive substances after an IED has exploded

Since considerable radiation exposure may occur when an IED has exploded, a concept was developed which stems this release. This led to the development of a widely remote-controlled wrapping of the IED, which is filled with foam with a high portion of water. The water destroys the energy of the explosive and the foam serves holding widely back the radioactive particles.

The following prerequisites are fulfilled by this concept:

- the IED need not be moved nor touched
- the wrapping can be transported in a normal car
- the wrapping can be installed wearing a deactivator suit
- the wrapping can include the deactivating device
- the time for installation is less than 30 minutes
- usual installations and possibilities of fire brigades, like hose couplings, water, air and extinguishing foam, can be used.

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ITRAP - The Illicit Trafficking Radiation Assessment Program

XA9848236

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Abstract

The paper describes the design and preliminary results of an extended pilot study of commercially available monitoring systems for the detection of nuclear and other radioactive materials at borders. The study consists of a laboratory test phase and field tests at the Austrian/Hungarian border and the Vienna airport, each for a duration of one year. The results will be used to derive realistic performance requirements for border control systems in view of optimized technical and economic conditions.

1. Introduction

In support of the IAEA program to combat Illicit Trafficking in nuclear and other radioactive materials the Austrian government contracted the Austrian Research Centre (ARC), Department of Radiation Protection to conduct a pilot study on border monitoring systems to evaluate the performance of commercially available equipment under realistic conditions in order to derive essential performance requirements for the upcoming IAEA "Safety Guide on Preventing, Detecting and Responding to Illicit Trafficking in Radioactive Materials". The ITRAP study has started in late 1997 and will be conducted during the next two years. The project is focused on detection at borders related to

- smuggled radioactive sources posing a potential health risk to the population, especially if illegally disposed;
- radioactive or nuclear materials used for terrorist activities with the inherent threat of creation of weapons of mass destruction.;
- radioactive materials in scrap metals causing substantial problems in the steel manufacturing process;

2. Scope of the ITRAP Study

The ITRAP study consists of three major phases.

In the first phase equipment currently available on the market and provided free of charge by interested manufacturers is subjected to laboratory testing at the Austrian Research Centres Seibersdorf. The instrument categories include hand-held, portable, and fixed-installed equipment. The test criteria defined as minimum requirements have been established together with the manufacturers. The laboratory tests started in May 1998 and will last until end of this year.

During the second phase, the field study, equipment passing the laboratory tests will be installed at a major Austrian-Hungarian border crossing (Nickelsdorf) for monitoring of cars, trucks and trains, as well as at the Vienna airport for pedestrians, luggage and cargo. In this phase the results gained from the lab tests about the 'fitness for use' shall be verified in practice, in close co-operation with the law enforcement officers at the borders. Also training issues and questions of maintenance and support shall be evaluated.

In the third phase realistic specifications and performance requirements shall be derived with the help of international experts and selected specialists from the users and manufacturers. The results of the field study will focus not only on the technical aspects of monitoring equipment (e.g. detection threshold and rate of false alarms) but also on the operational (e.g. ease of use, reliability, training requirements, field support) and economic aspects of extended border installations.

3. Realization

The pilot study is being undertaken in close co-operation with the IAEA and a panel of experts who already defined the test procedures and minimum requirements for the lab tests together with the manufacturers. For the practical implementation of the equipment in the field, the excellent co-operation with the Austrian and Hungarian customs authorities is greatly acknowledged.

The lab test was launched on May 27th, 1998, after initial set-up problems. By mid July about 20,000 tests have been made under alarm conditions (elevated background plus source present) and approximately 30.000 tests under false alarm conditions (source absent, only elevated background).

4. Lab-Test Conditions

Totally 14 fixed installed systems have been positioned in a circular (panoramic) geometry around a circle of 3 m radius, with the reference point of the detector exactly at the same distance from the centre of the circle for all systems (fig.1). If a detector system consists of two detectors, only one of them has been used for the tests. At the test-site the portals with detectors have been installed in a fenced open area, unprotected to environmental conditions, the electronics and control-units in an adjacent, protected and enclosed hall.

To test the detection probability a source of about 10 MBq ^{137}Cs is positioned in a shielding container at the centre of the circle and raised out of the shield for a duration of 1 second. The dose-rate during the exposure period of 1 s is 0,1 µSv/h at the reference point of the detectors. After each exposure the source is lowered into the shield for 1 minute, than raised again. With continuos operation some 10,000 exposures can be made within some 10 days. An additional ^{137}Cs source at the centre (above the moveable source) increases the natural background to approximately 0.2 µSv/h at the reference point. The exposures have been repeated with lower number of shots with an ^{241}Am and an ^{60}Co source of the same dose rate. To test the neutron response of the detector systems a ^{252}Cf source of 0.2 MBq (0.01 µg) is used which emits the same neutron flux as 300 g of weapons Plutonium (6% ^{240}Pu).

To test the **false alarm** rate the same set-up is used without a source in the shield (only background source).

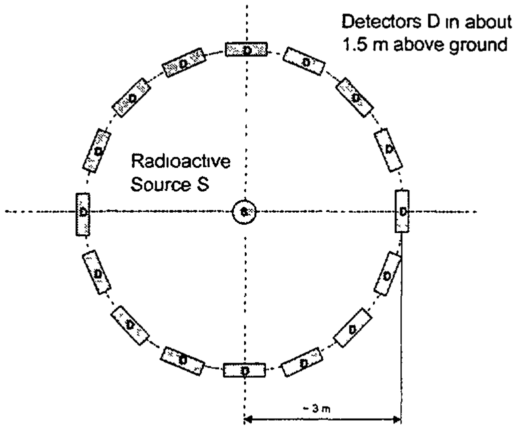

Fig. 1: *All detector systems are tested simultaneously using a circular (panoramic) geometry around a circle of approximately 3 m radius with the radioactive source in the centre.*

Fig. 2 shows the time regime for one test cycle. The electronic control system provides a start and a stop control signal to define the occupancy time period, the instruments under test provide an alarm signal if an alarm is triggered. Every 0.5 s the status of all detector systems is recorded simultaneously on PC together with the source position and measured dose rate. During a one minute waiting-period after each exposure the systems may perform automatic re-calibration.

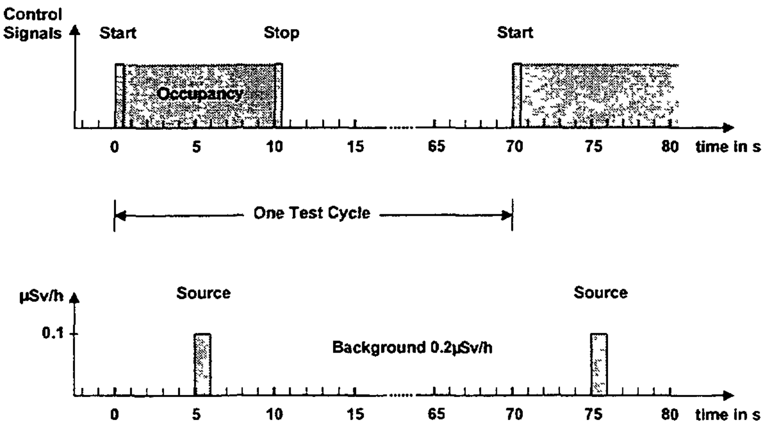

Fig. 2: *Timing regime for one test cycle*

5. Preliminary Results

Fig. 3 is a summary of the preliminary results for the alarm tests. Under alarm conditions (elevated background plus source present), the average failure rate, i.e. the frequency to trigger no alarm when the source is out of the shield, is generally below 1 in 1000 incidents, with an average of 2.10^{-3}. Best system performance is below 1 missed alarm in 10.000 (practically NIL), worst performance is in excess of 1 missed alarm in 100. Generally the system performance is rather uniform with a few exemptions, i.e. rather good and rather bad performance.

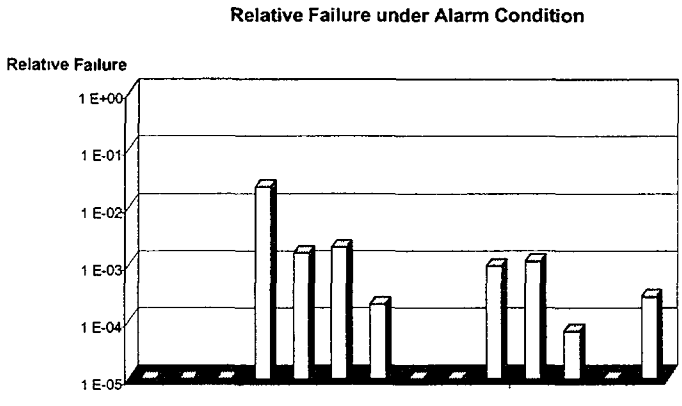

Fig. 3: *Relative Failure under alarm conditions (background plus source)*

The false alarm rate, i.e. the frequency of alarms triggered without a source, was also evaluated under the same timing and background conditions, however without a source present. Variations among the systems are much more pronounced here, indicating problems to cope with elevated background situation and others. Following discussions with manufacturers it is not yet clear, if spurious effects (e.g. temperature drift) or lack of calibration cycles might be the cause. However, a number of systems (about 40%) have passed the tests with practically zero false alarms so far. For other systems there seems to be a correlation between excellent performance under alarm conditions and poor false alarm rate, as can be expected. Generally, the average false alarm rate is 0.6%, mainly caused by 3 rather poor systems clustering in the 1% region. Ignoring these systems, average false alarm rate would drop to 0.03%

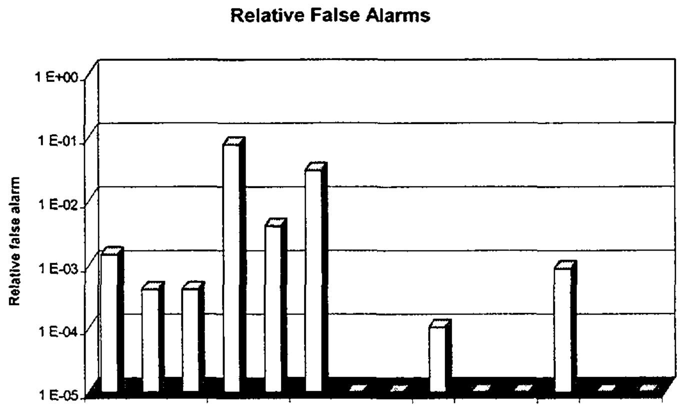

Fig. 4: *Relative False Alarms under no-alarm conditions (background only)*

6. General observations

The agreed minimum requirements and resulting test conditions – both the radiological as well as the environmental specifications – seem to pose considerable problems for some of the systems. After about 10,000 tests five manufacturers had to be called in for repair of their systems, which became obvious by sustained bad performance both in detection failure and false alarm rate, although these systems behaved well in the beginning. Bad set-up, bad internal adjustment to the timing regime or bad environmental compatibility may have been the possible reasons for some of the bad results. Testing was halted and the resumed when the 5 candidates were again ready to join the experiment. It has been observed that only long term tests under controlled laboratory conditions may reveal shortcomings in equipment design which will not show up in a short term testing, mostly applied in this field up to now. The exact nature of these effects is not obvious and may be specific for every individual equipment under test. Eventually, discussions with the manufacturers should reveal the exact reasons for the system behaviour experienced so far. However, for the purposes of ITRAP the immediate results are a general indicator of instrument reliability. Under field conditions, which will include even harsher environmental and less controlled operating conditions, such false alarms rates or failed detections might either go unnoticed or create a considerable nuisance for the operating personnel.

7. Conclusion

Interesting results have been achieved so far for the gamma radiation tests which have given rise to detailed discussions with selected Suppliers. Most of the systems participating in the test can be ranked under good performance, however, there are also a number of problems associated with other systems that have to be rectified to ensure flawless performance under simulated scenarios or "real world conditions". With the laboratory tests not completed, it is still premature to reach a final conclusion on instrument performance. Further information will be released in agreement with the suppliers on general and individual performance results as soon as available.

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TEST AND EVALUATION OF ISOTOPE IDENTIFIERS

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Abstract

Three devices were tested against eighteen radio-isotopes ranging in activity from 0.37 kBq (K-40) to 93.24 GBq (Pu-239) to determine their effectiveness as isotope identifiers. Two of the devices were hand-held instruments using NaI(Tl) detectors and the third one was a bench-top instrument using a mechanically-cooled Ge detector. Details of the test and the test results are presented in this paper.

1. Introduction

The dissolution of the Soviet Union has resulted in an increased risk of proliferation of special nuclear material (SNM) throughout the world. U.S. Customs Service is embarked on a program to detect and identify nuclear contraband as part of the its nuclear non-proliferation effort. The development, test and evaluation of radiation detection devices which can also identify the radio-isotopes is an essential part of this program.

The radiation detection and isotope identification devices used by the U.S. Customs Inspectors have to be small in dimensions (preferably hand-held), should not be heavy (about 2 kg) and should be easy to operate. The typical Customs Inspector does not have either the ability or the time to analyze the spectrum displayed by commercially available compact multi-channel analyzers. Hence, U.S. Customs Service has made it a requirement that the display of the instrument should indicate what the detected isotope is (e.g. Tc-99m, Cobalt-60 or U-235), and to what category it belongs (e.g., medical, industrial or SNM) and it should do so in a reasonably short time such as 30 to 45 seconds.

Actually, the U.S. Customs Service has a two-tier system for the interdiction of radioactive contraband in commercial traffic. The first tier consists of the Radiation Pager which not only detects the presence of low levels of radiation above background but can also be used to localize the source of radiation. The second tier consists of the Isotope Identifier which is used to identify the isotope and place it in one of the three categories: medical, industrial or SNM. The Customs Inspectors then have to follow a standard operating procedure based on what that category is.

2. Description of the test

The tests were conducted at the Remote Sensing Laboratory (RSL) at Las Vegas, Nevada and the Special Technologies Laboratory (STL) at Santa Barbara, California during December 1997 and April 1998. The list of radio-isotopes against which the instruments were tested is given in Table 1, arranged in the three categories mentioned above.

Table 1. Radio-Isotopes (and Their Half-lives) Used in the Test and Evaluation of Isotope Identifiers.

Medical Radio-isotopes		Industrial Radio-isotopes		Special Nuclear Material	
Ga-67	(79 h)	K -40	(1.3e9 y)	U-233	(1.6e5 y)
Tc-99m	(6 h)	Co-57	(271 d)	U-235	(7.04e8 y)
In-111	(67 h)	Co-60	(5.27)	Pu-239	(2.41e4 y)
I-131 [a]	(8.05 d)	Ba-133	(10.6 y)		
Xe-133	(5.2 d)	Cs-137	(30.2 y)		
Tl-201	(73 h)	Ra-226	(100 y)		
		Th-232	(1.4e10 y)		
		U-238	(4.47e9 y)		
		Am-241	(432.2 y)		

a. The gamma-ray spectrum of I-131 was simulated with Ba-133 and Cs-137 in the right proportion by activity.

The following procedure was followed during the test: Activity, physical form and containment of each radioactive source was recorded in a specially prepared data sheet. Since the medical isotopes have very short half-lives, the time when they were used was also recorded. Each source was set at distances of 30, 60 and 120 cm from the instrument. For the reading at each distance, the dose rate at the front of the instrument was recorded using a separate survey meter. The spectral data was acquired for 30 seconds and the result displayed by the instrument was recorded in the data sheet. Shield materials of different type (aluminum, steel, cadmium and lead) and different thickness were used with SNM. The time allowed for the decision algorithm to come up with an answer was 10 seconds after the 30 seconds of data acquisition.

3. Brief description of the devices

Device 1 was a hand-held instrument containing a 38.1 mm x 38.1 mm x 5.08 mm NaI(Tl) scintillating crystal as the radiation sensing element. This instrument had the dimensions 101 mm x 228 mm x 89 mm and weighed 2.2 kg. Device 2 was also a hand-held instrument but it contained a 29 mm in diameter and 51 mm long NaI(Tl) scintillating crystal. Its dimensions were 168 mm x 158 mm x 73 mm and it weighed 2.95 kg. Device 3 was a bench-top instrument and it contained a small mechanically-cooled intrinsically pure germanium detector as the sensing element. It dimensions were 152 mm x 152 mm x 457 mm and it weighed 25 kg.

Device 1 and 2 had the control buttons and black-and-white liquid crystal display on top of the instrument. Device 3 used a note-book computer with colored liquid crystal display for operation . All three displays identified the isotopes with the category (medical, industrial or SNM) with some variations. In addition, Device 2 display had a bar indicator which told the operator to move closer to the source if the radiation level was too low or to move further away if the radiation level was too high for a proper determination before it displayed the result.

Calibration with a Cs-137 check source (Device 1 and Device 3) and a Bi-207 check source (Device 2) was required each morning when the instrument was turned on first thing in the morning.

4. Test Results and Discussion

A very large number of trials (~ 100) were made with each instrument. The overall success rate expressed in terms of percent correct determinations is given Table 2 for the three devices.

Table 2. The Overall Success Rate

Device 1	Device 2	Device 3
78%	66%	84%

The success rate for a given instrument depends on a number of factors. These include the sensitivity and the energy resolution of the detector element, the accuracy of the algorithm used for the spectral identification, the gamma-ray spectrum of the radio-isotope and the activity of the source. Since the sensitivity of the sensing element depends on its volume (other factors being the same), it is to be expected that Device 1 will be more sensitive than Device 2. This will result in a better success rate for Device 1 than for Device 2 as shown in Table 2.

Furthermore, since the energy resolution of NaI (Tl) crystals is about 7.5% and that of pure germanium crystal is 0.1%, the later will make more correct determinations simply because of the fact that the gamma-ray spectral lines are much sharper, assuming the same algorithm is used for identification. This is shown in Table 2 where the success rate for Device 3 is better than for either Device 1 or Device 2.

The detector efficiency of sodium iodide detectors varies inversely as the square root of the energy of the gamma-ray being detected. This means that photons of higher energy such as 1 MeV are detected with less efficiency than photons of lower energy such as 100 keV. For energies lower than 100 keV, say around 50 keV, the instrument casing begins to absorb the gamma-rays and associated x-rays more strongly so that not enough of them reach the sensing element, resulting in decrease in efficiency. This is important to know since the energies of the gamma-rays ranged from 80 keV to 2.2 MeV in the radio-isotopes used for the test and will have a bearing on the test results for a given instrument.

Ease of use is a very important attribute of any instrument which will be used in the field by Customs Inspectors. Device 1 was easier to handle than Device 2 because of more balanced construction, less weight, and the presence of a handle. Its display was also easier to read. *Device 3 is more suitable for use near conveyer belts carrying parcels and luggage. In this* scenario it can be operated remotely.

With the introduction of the Radiation Pagers, there are incidents of radiation alerts at Ports of Entry whereas these were non-existent before. These alerts are caused mostly by passengers who have received medical treatment with radio-isotopes. It is estimated that 90% of the alerts are situations like this. The rest are medical or industrial isotopes in shipping containers which do not have proper shipping labels. Even if a shipping container has labels or markings indicating that it contains a certain type of radioactive material, it may be necessary to verify the identity of the material in it because the label may contain false information. We are definitely interested in the interdiction of nuclear contraband; however, it is also imperative that nuisance alarms (false alarms) from passengers who have been treated with medical isotopes or improperly marked shipping containers of medical and industrial isotopes be eliminated as a possibility so that the Customs Inspector's time and effort is not wasted. Hence, more emphasis should be placed in quickly resolving situations which result in false alarms.

All three devices obtained the gamma-ray spectrum of the isotope presented to them and analyzed them to make an identification. It is well known that Pu-239 fissions spontaneously to give off high energy neutrons. The identification of this particular material can be made faster by incorporating a neutron detector in the same instrument which detects gamma rays.

5. Conclusions

Three devices were tested against a large number of radio-isotopes including SNM. The results show that these devices showed varying degrees of success rates due primarily to the type and size of the detector element and the sophistication of the algorithm used to identify the gamma-ray spectra.

6. Acknowledgments

The assistance of John Pittman of Special Technologies Laboratory and Rich Waters and Rick Hansen of Remote Sensing Laboratory is gratefully acknowledged.

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CUSTOMS CONTROL OVER THE TRANSPORTATION OF RADIATION SOURCES AND RADIOACTIVE MATERIALS THROUGH THE FRONTIER OF THE REPUBLIC OF BELARUS

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Abstract

1. *As it is shown in the name the main purpose of this Paper is to describe system of customs control over transportation of radiation sources and radioactive materials through the frontier of the Republic of Belarus, clarifying herewith influence of global situation on the creation of this system and noting technical needs of Customs Administration of Belarus in its activities aimed at strengthening the control system.*
2. *The Republic of Belarus has not the enterprises of atomic-industrial complex and does not produce radioactive and nuclear materials, so, control over them is largely connected with their transit through frontiers of Belarus and its territory. It is necessary to note, that the frontier of Belarus with the Ukraine, Poland and Baltic States is an external frontier of a Custom Union between Belarus, Russia, Kazakhstan and Kirghizia. On the territory of the last three states are concentrated extraction and production of radioactive and nuclear materials, part of which can be transported by the shortest way to the European countries through the territory and frontiers of the Republic of Belarus.*
3. *The significant part of the republic territory (about 20 %) suffered from Chernobyl catastrophe. In a number of the polluted regions of Belarus there were created the zones of «moving people further out», the residing on them is prohibited by legislation. On those territories there were created numerous burial grounds for the conditionally radioactive and low radioactive wastes. In this connection, there is also a danger of illegal importation of various radioactive wastes from contiguous countries to these zones and burial them there. On the other hand, there are known the numerous cases of exportation of various materials, subjects, food from the polluted zones even out of Belarus.*
4. *Taking into account the aforesaid the Customs Administration of the Republic of Belarus as well as other public authorities, clearly recognizes the necessity of organization of an effective radiation control on customs frontiers and on the territory of Belarus, so, for these purposes there was developed the special legislation consisting of international instruments and national governmental acts. The main of them are International Program INTAR, Governmental Act of March 18, 1997 «About establishment of the interdictions and limitations on movement of things through customs border of the Republic of Belarus»; Agreement between the Republic of Belarus and the United States of America concerning liquidation of consequences of emergencies and prevention of proliferation of the weapons of mass destruction of October 22, 1992, Protocol between Customs Services of Members of the Commonwealth of Independent States on interaction in organizing the customs control over fissionable and radioactive materials of May 21, 1998, Law of the Republic of Belarus «About radiation safety of the population» of January 5, 1998, Order of the Customs Administration of the Republic of Belarus «About the customs control over radioactive substances» of December 23, 1997, Regulations on the control over radioactive contamination of the Republic of Belarus by Chernobyl catastrophe, and others.*

5. *On the basis of the named documents the Customs Administration works on organization of an effective customs control over the transportation of radiation sources and radioactive materials through the frontier of the Republic of Belarus. Actually this control covers the following tasks: ensuring radiation safety of the population of the Republic of Belarus, suppression of illegal movement of fissionable and radioactive materials through customs border, revealing of offenses of customs and other laws. It is carried out in conformity with international standards and consists of: primary radiation control, additional radiation control and detailed radiation examination.*

It is well understood that organization of an effective radiation control largely connected with personnel training and acquisition of special equipment. In this fields the Customs Administration of Belarus received a significant assistance from customs administrations of Austria, Germany, Finland, France, the United States of America, Russian Federation. So, Customs Administration of Belarus expresses its acknowledgments to them for the rendered assistance.

1. Introduction

1.1.. Actually Governments of majority of countries of the world realize in full measure necessity of the strict control over unauthorized movement of the radioactive and nuclear materials through state frontiers. In the light of this they made emphasis on creation of such control systems, which represent a complex of means having high sensitivity to detection of small quantities of radioactive and nuclear materials, including special materials (for weapons).

1.2. The given situation took shape because the last years the world community is facing a problem, which until now was considered as an abstract problem connected with possibility of partial or even full run of proliferation of nuclear and radioactive materials out from control. On the one hand, this process was sharply sped up by disintegration of the USSR, and, on the other hand - by general development of high technologies in the world, that allowed a number of the states to create their own nuclear or radiological weapons.

1.3. In connection with aforesaid the traditional «paper-registration» control system of movement of radioactive and nuclear materials both inside the states and through their frontiers became less effective. Besides, decentralization and intensification of trade in fissionable and radioactive materials resulted in growth of their carriages and became reasons of a problem connected with strengthening of measures aimed at safety of transportation of similar materials. In existing concept of safety is put not only traditional staff and environment protection during transportation of the indicated materials, but also economic protection connected with a problem of confirmation of isotope structure (under the nomenclature and quantity) stated while dispatching.

2. Prerequisites of creation of radiation control system in the Republic of Belarus

2.1. General prerequisites

2.1.1. The Republic of Belarus has not the enterprises of atomic-industrial complex and does not produce radioactive and nuclear materials, so, control over them is largely connected with their transit through frontiers of Belarus and its territory. It is necessary to note, that the frontier of Belarus with the Ukraine, Poland and Baltic States is an external frontier of a Custom Union between Belarus, Russia, Kazakhstan and Kirghizia. On the territory of the last three states are concentrated extraction and production of radioactive and nuclear materials, part of which can be transported by the shortest way to the European countries through the territory and frontiers of the Republic of Belarus.

2.1.2. Besides, the significant part of the republic territory (about 20 %) suffered from Chernobyl catastrophe. In a number of the polluted regions of Belarus there were created the zones of «moving people further out», the residing on them is prohibited by legislation. On those territories there were created numerous burial grounds for the conditionally radioactive and low radioactive wastes. In this connection, there is also a danger of illegal importation of various radioactive wastes from contiguous countries to these zones and burial them there. On the other hand, there are known the numerous cases of exportation of various materials, subjects, food from the polluted zones even out of Belarus.

2.1.2. In this connection, creation of system of the radiation control on Byelorussian frontier is an actual problem for ensuring economic and political safety of the State and safety of its citizens. This system already has certain normative base.

2.2. Legal prerequisites

2.2.1. The Republic of Belarus, as the Member of International Atomic Energy Agency, Custom Union of the four CIS countries, Union with Russia, confirmed creation of a system of the radiation control on the state frontier pursuant to the following international obligations and republican acts:

- International Program INTAR (Illicit Trafficking Radiation Assessment Program) aimed at prevention of illegal movement of radioactive and fissionable materials through customs borders;
- Decision of the Council of Ministers of the Republic of Belarus of March 18, 1997 N 218 «About establishment of the interdictions and limitations on movement of things through customs border of the Republic of Belarus»;
- Agreement between the Republic of Belarus and the United States of America concerning liquidation of consequences of emergencies and prevention of proliferation of the weapons of mass destruction of October 22, 1992;
- Perspective plan of cooperation of Members of the Commonwealth of Independent States in peaceful use of atomic energy and increase of safety of nuclear installations of January 17, 1997, aimed at cooperation between customs and special services, ministries and departments on counteraction to an illegal turn-over of nuclear and radioactive materials - section 1.4.;
- Protocol between Customs Services of Members of the Commonwealth of Independent States on interaction in organizing the customs control over fissionable and radioactive materials of May 21, 1998, aimed at establishment of an order of informing and interaction of Contracting Parties in cases of illegal movement of fissionable and radioactive materials through customs borders;
- Law of the Republic of Belarus «About radiation safety of the population» of January 5, 1998, determined fundamentals of the law regulation in the field of radiation safety of the population. These fundamentals are aimed at creation of conditions ensuring life and health protection of the people from harmful effect of ionizing radiation;
- Order of the Customs Administration of the Republic of Belarus «About the customs control over radioactive substances» of December 23, 1997 N 434 determined the order and operations of the officials of customs service as well as of other competent bodies while movement of fissionable and radioactive materials through customs borders of the Republic of Belarus;
- Regulations on the control over radioactive contamination of the Republic of Belarus by

Tchernobyl catastrophe determined a network of divisions of the radiation control on the territory of the Republic of Belarus and their competence;

- Regulations about organization of customs researches and examinations in customs service of the Republic of Belarus (adopted by Order of Customs Administration on December 19, 1994 N 377) determined conditions and order of production of customs researches and examinations in customs service as well as order of withdrawal, packing, transportation, registration, storage and disposal of samples and specimens taken for customs research.

3. Elements of control system

Pursuant to the above-stated the customs service of Republic of Belarus determined the following tasks of the customs control over fissionable and radioactive materials: ensuring radiation safety of the population of the Republic of Belarus, suppression of illegal movement of fissionable and radioactive materials through customs border, revealing of offences of customs and other laws.

3.1. Object and forms of control

3.1.1. Objects of the customs control over fissionable and radioactive materials are goods under the customs control, and means of transport moved through customs border of the Republic of Belarus.

3.1.2. The customs control over fissionable and radioactive materials is carried out in the forms of:

- survey of appearance of transport packing kits (sets) for their conformity to established requests;
- examination with use of technical means, as the primary radiation control and additional radiation control;
- customs research as detailed radiation examination.

3.2. Stages of Control

The customs control is carried out in case of availability of information about movement of radioactive substances as well as by selection (under solution of the customs officials) and includes the following stages: primary radiation control, additional radiation control, detailed radiation examination.

3.2.1. Primary radiation control with the use of stationary radiation control systems (SRCS) is carried out before presentation of goods and means of transport for customs clearance. The primary radiation control is carried out in cases when in point of customs clearance there are no SRCS, but there are dosimeters-warning indicators.

3.2.2. The primary radiation control on the frontier is made in an automatic regime by automobile stationary systems of radiation control (ASSRC). The activity on the primary radiation control was begun in the republic in 1994 by installation of SRCS (production of French firm NARDEUX) in border crossings «Kozlovichi» and «Warsaw Bridge». In 1996 five border crossings (Berestovitsa, Bruzgi - Grodno custom-house; New Guta - Gomel custom-house; Kamenny Log, Kotlovka - Oshmyany custom-house) were equipped with ten SRCS (production of byelorussian firm POLYMASTER). Besides, within the framework of the Nann-Lugar Program to the Republic of Belarus there were delivered 36 foot SRCS (production of the company RADOS) and one SRCS (production of the company LUNDLUM) - within frames of cooperation between special services of the Republic of Belarus and the USA.

3.2.3. Additional radiation control is carried out after presentation of things to customs clearance with use of devices of the radiation control intended for determination of concrete parameters of measured values. This control includes localization of a radiation source in case of SRCS operation and its primary identification in field conditions, determination of availability of surface contamination of objects by alpha and beta radiation sources. The additional radiation control is made by portable devices intended to be operated in severe conditions.

3.2.4.1. A limited number of portable search screen monitors PRM-470 and GATEMAN (production of the American companies) were delivered to customs services of the Republic of Belarus within the framework of the Nann-Lugar Program.

3.2.4.2. Tasks of the additional radiation control:

- finding out the reasons of SRCS operation or of radiation control devices;
- locating a source of ionizing radiation;
- separating the radiation consignment and people; isolation of the revealed object, which contains a source of ionizing radiation with observance of norms of radiation safety.

3.2.5. Detailed radiation examination is carried out in accordance with «Regulations on organization of customs researches and examinations in customs service of the Republic of Belarus».

3.2.6. The selection and taking of samples for customs research is carried out by the customs officials authorized to realize customs control over radioactive materials, independently, or with engaging of the experts from specialized divisions. Upon termination of examination the customs officials should receive from the experts of customs laboratory or specialized laboratories the following: conclusion about reference of sample to radioactive substance, determination of its radio-isotope (qualitative) and quantitative structure and specific activity of substance, and also recommendation for radiation safety.

3.2.7. The customs official is made a decision: about issue of the sanction on movement through customs border or on fulfillment of operations determined by a customs procedure; about detention (withdrawal) or return of the radiation consignment if it is not smuggling.

3.3. Information necessary for registration (in case of detention of the means of transport)

3.3.1. Customs officials enter the following data in the register for means of transport:

- date and time of operation of devices;
- information on the driver and accompanying persons (name, passport data, place of activity and post);
- name of the enterprise-receiver, enterprise-shipper with the indication of addresses;
- name of the enterprise-carrier with indication of address;
- type of the means of transport, number, model;
- name, quantity, character of the consignment;
- availability of the permission on movement of radioactive substances/materials issued by Atom Supervision Body (Promatomnadzor) under Ministry on Extraordinary Situations of the Republic of Belarus.

3.3.2. If necessary, more detailed information is recorded or the copies of customs, transport and other documents are made. The above-stated information is entered in the register for all means of transport moving the radiation consignments through customs border of the Republic of Belarus (with or without permission of Promatomnadzor).

4. Needs of Customs Administration in creation of more effective control system

4.1. Actually, with the purposes to produce more effective customs control over fissionable and radioactive materials moved through the frontiers of Belarus the customs service of the Republic of Belarus has to be equipped with the following means of the radiation control:

	Name	Quantity
1.	Transport monitor	54
2.	Searching microprocessor dosimeter	138
3.	Radiometer-dosimeter universal	20
4.	Mail-baggage monitor	2

5. Conclusion

5.1. In conclusion it is necessary to note that the system of the radiation control over fissionable and radioactive materials in the Republic of Belarus is in process of active creation. It is connected first of all with the realizing, both by byelorussian population and by public authorities at all levels, the danger for people and environment hidden in illicit transportation of fissionable and radioactive materials as well as the linking with this proliferation of nuclear and mass destruction weapons. To an even greater degree the creation of the named system connected with liquidation of Chernobyl catastrophe consequences.

5.2. It is well understood that organization of an effective control over the materials in question demands from the competent public services, in particular from the Customs Administration of Belarus authorized to produce the named control, to develop legal basis, to train the staff and to equip specialized divisions. As for legislation and training - they are prepared, but acquisition and installation of equipment are in process of realization and connected with financial means.

5.3. Customs Administration of Belarus expresses acknowledgments to the international community for assistance rendered within the frameworks of special programs - significant assistance in acquiring equipment and personnel training were received from the United States of America, France, Germany, Austria, Finland and other countries. Customs Administration of Belarus is especially thankful to the Customs Administration of the Russian Federation for permanent help in all spectrum of customs matters.

DETECTION AND IDENTIFICATION TECHNIQUES FOR ILLICITLY TRAFFICKED RADIOACTIVE MATERIALS

(Technical Session 9)

IAEA-CN-70/108

RADIATION PORTAL EVALUATION PARAMETERS

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Abstract

The detection of the unauthorized movement of radioactive materials is one of the most effective nonproliferation measures. Automatic special nuclear material (SNM) portal monitors are designed to detect this unauthorized movement and are an important part of the safeguard systems at US nuclear facilities. SNM portals differ from contamination monitors because they are designed to have high sensitivity for the low energy gamma-rays associated with highly enriched uranium (HEU) and plutonium. These instruments are now being installed at international borders to prevent the spread of radioactive contamination and SNM. In this paper the parameters important to evaluating radiation portal monitors are discussed.

1. Introduction

Automatic pedestrian and vehicle portal monitors have been an established tool for controlling the movement of radioactive material at US nuclear facilities for 15 years. The technology of automatic pedestrian and vehicle monitors was developed at Los Alamos National Laboratory (LANL) in the 1970s and early 1980s.[1,2,3] These monitors were specifically designed to detect the presence of special nuclear material (SNM) by comparing the gamma-ray and neutron intensity while occupied to the background radiation level which is measured while the monitor is unoccupied. The measured gamma-ray background level is used to update the alarm threshold to maintain a constant false-alarm rate. SNM portals differ from contamination monitors because they are designed to have high sensitivity for the low energy gamma-rays associated with highly enriched uranium (HEU) and plutonium. SNM monitors are highly effective contamination monitors but contamination monitors are not necessarily effective SNM monitors. SNM portals generally consist of two vertical cabinets containing both large plastic scintillators and decision-making electronics.

SNM monitors were designed to control the unauthorized movement of SNM at nuclear facilities. Radiation monitors used to control the movement of radioactive material across international borders do not require the same sensitivity as those at nuclear facilities. Although some effort will be required to tailor these instruments to this new application, the effective operation will depend on the same operational parameters.

2. Important Parameters

The purpose of a radiation portal monitors is to detect the presence or movement of radioactive material. Therefore, the sensitivity should be quoted not at its most sensitive area but, at its least sensitive area. That is, what is the largest amount of radioactivity that can pass through the monitor without being detected. To evaluate a monitor, its sensitivity should be mapped to determine the region of least sensitivity. Figure 1 shows a vertical profile for a portal monitor using plastic scintillators as detectors. Although there is a drop in sensitivity in the vertical center of the portal, the regions of least sensitivity are at the bottom and the top of the monitor. For pedestrian monitors, the region of least sensitivity is the bottom of the monitor because the measurement time for a person's foot passing through the monitor is less than the rest of the body. After the region of least sensitivity has been determined, horizontal sensitivity plots, which simulate vehicle or pedestrian passage, can be used to determine the smallest detectable amount of radioactivity. An example of this plot is shown in Figure 2.

Determining the sensitivity for vehicle monitors is more difficult because the amount of shielding available varies for different vehicles. However, the potential for shielding is greatest near the engine block and the vehicle axles. Therefore, the sensitivity should be quoted for sources placed in these areas. This is why a simple truck bed monitor which monitors contaminated steel is not necessarily an effective radiation monitor for a border crossing.

The comparison of radiation monitors is difficult because the proper quotation of sensitivities is very complicated. When quoting instrument sensitivities, the false alarm rate and the radiation background level must be quoted. The detection thresholds of contamination monitors are normally quoted in dose rate in μSv/h while SNM monitor sensitivities are quoted in terms of the minimal detectable mass of SNM. A quote in μSv/h must include the gamma energy and the distance between the source and the instrument. Instruments that read in μS/h are calibrated for one energy (usually ^{137}Cs) and a correction must be applied for all other energies. A quote of the minimum detectable mass must include the isotope, the enrichment, and the form and the shape of the material. The form and shape of SNM is important because the material is extremely self-absorbing. Thin sources, powders, or foils emit most of their radiation whereas more compact shapes such as metallic spheres and cylinders reabsorb 90% of their radiation. Therefore, if a manufacturer quotes a minimal detectable mass of 10g without stating the physical form of the material, the uncertainty in the sensitivity is more than a factor of 10.

A very important step in the evaluation of any monitor is measuring the monitor's false-statistical alarm rate because the detection sensitivity is closely related to this value. This requires interrupting the monitors occupancy sensor automatically for short periods (1 minute or so) of occupancy and allowing the background level to be updated between test periods. The key to the detection of SNM is to achieve a lower level discriminator setting that allows for the detection of low energy gamma's without counting significant electronic noise. A small amount of electronic noise can significantly effect the false-alarm rate. Therefore, the false-alarm rate must be measured rather than merely calculated. To establish the false-alarm rate for an alarm threshold of 4σ, which has a calculated false alarm rate of 1 in 30,000 tests, approximately 0.5 million tests are required. Results of the false alarm testing should fall within a factor of 2 of the calculated value if the electronic noise level is not contributing significantly to the rate.

Besides the sensitivity of the detector, the detection algorithm is also important. In walk-through pedestrian monitors, pre-counting and post-counting capabilities are important. That is, the monitor should include counting time prior to being occupied and after it has been occupied as part of its decision making process. These capabilities are important because it greatly reduces the effects of body shielding.

For comparing plastic scintillator based monitors, their sensitivity to a particular isotope can be determined by using a signal-to-noise ratio as a figure-of-merit (FOM). A larger FOM indicates better performance. The signal used is the net count produced by the desired isotope positioned at an appropriate location on the monitor. The net count, S, is calculated by subtracting a background count, B, from the total count, S + B, measured with the source positioned in the monitor. The background count, B, is measured with no source present. The noise used in the FOM is the statistical variation in the background measurement. For gamma-ray monitors, the statistical variation can be estimated by the $\sqrt{B}$, which is the standard deviation of the measurement. The ratio of S to the $\sqrt{B}$ shows how large the net signal is in comparison to the normal statistical variation in the monitor's background measurements. Hence, obtaining the largest possible FOM without increasing the statistical false alarm rate, is directly related to obtaining the best performance.

$$FOM = S/\sqrt{B}$$

This FOM is very useful for comparing the detection threshold of different monitors for the isotopes of interest.

3. Conclusion

Selecting the best radiation monitors to prevent the transportation of radioactive materials across international borders is not a simple task. The nuisance alarm rate must be low enough to not significantly impede the normal flow of traffic. A nuisance alarm is an alarm which the result of material with normal or internationally acceptable levels of radioactivity passing through the portal and triggering an alarm. Achieving an acceptable nuisance alarm rate and still having sufficient sensitivity to deter the proliferation of nuclear weapons is a challenging endeavor. Only with the careful selection of the operating characteristics of the radiation portal monitors and the use of sophisticated portable isotope identification instruments is this goal achievable.

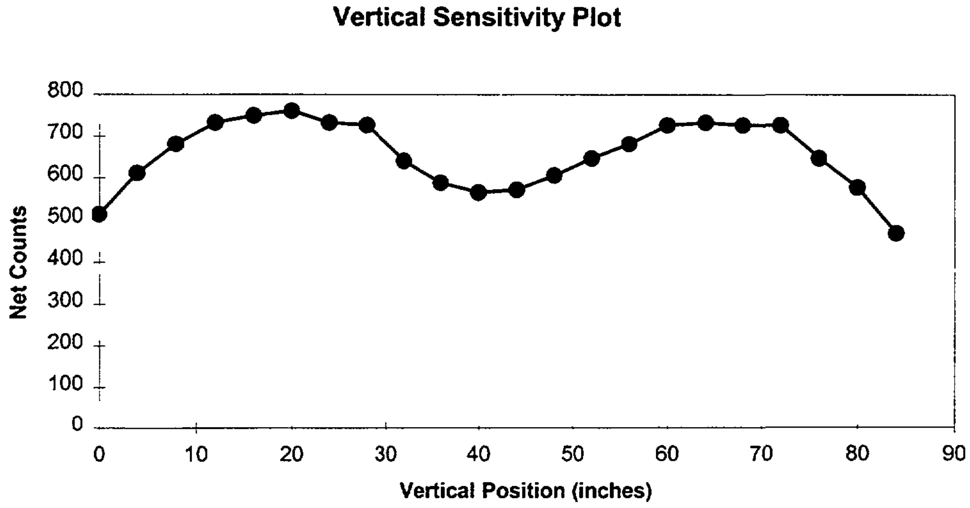

Figure 1. A vertical sensitivity plot to determine the region of least sensitivity.

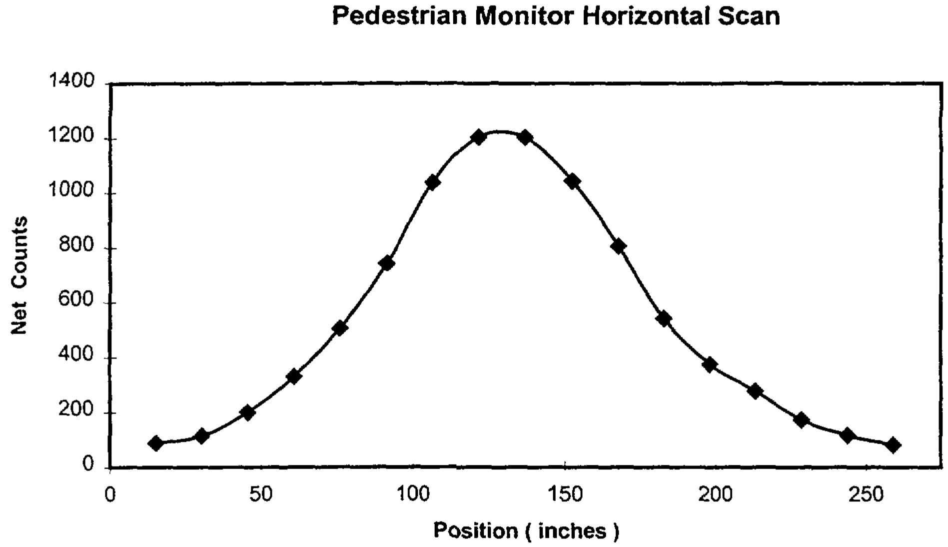

Figure 2. A horizontal sensitivity plot to calculate the minimum detectable sensitivity.

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EQUIPMENT OF HIGH SENSITIVITY TO DETECT SMUGGLED RADIOACTIVE MATERIALS TRANSPORTED ACROSS THE "EAST-WEST" BORDER

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Abstract

An equipment specially developed for the customs radiation control is described. Its sensitivity is higher than requirements of western countries. The equipment ensures an alarm when a radioactive source (both shielded or not) is found in the controlled area, localizes and identifies the source detected, and provides the radiation protection of customs personnel. Most of devices have a non-volatile memory where the radiation situation history is stored and then transferred to PC. The equipment may be used by personnel of special services for secret detection of radioactive materials. Some Belarussian and Russian documents specifying measures to prevent an unauthorized transportation of radioactive materials are discussed.

1. INTRODUCTION

The CIS western border is the western border of the Republic of Belarus and a demarcation line between "East" and "West" . The Republic of Belarus is a "non- nuclear" state, has no enterprises of nuclear industry, does not produce radioactive and nuclear materials. So, a control of these materials is caused to a considerable extent by their transportation through the state and across state borders. It should be noted that the western border of Belarus (adjoining the Ukraine, Poland and the Baltic states) is also the border of the customs Union that includes the Russian Federation, Belarus, Kazakhstan and Kirghizstan. Mining and production of radioactive and nuclear materials (including special nuclear materials) are mainly concentrated within the territories of the said countries. Some part of these materials may be transported (illicitly as well) to the West along the shortest way - across the Belarus borders and through its territory. Many cases of such a smuggled transportation are known.

Furthermore, a considerable part of the Belarus territory (about 20%) suffered the Chernobyl NPP accident. There are many evacuation zones in some radionuclide-contaminated regions where living is prohibited. However, there are numerous sites where conventionally radioactive and low radioactive wastes are buried. So, there is a danger of an unauthorized import of various radioactive wastes from neighbouring countries and their burial in these areas. On the other hand, numerous cases of export of substances, things, foods, etc. from contaminated areas outside Belarus are known.

Various countries have different state institutions that are responsible for the control of unauthorized transportation of radioactive materials. The State Customs Committee is such an institution in the Republic of Belarus. So, a great attention is centered on the Customs Control of transportation of Radioactive Materials (CCRM).

As early as in 1994, at the IAEA symposium a participant from Belarus was one of the first experts who arose a problem of CCRM realization using special equipment [1]. In the same year, Belarus was the first country in the CIS that installed fixed radiation monitors at the Belarus-Poland cross border point.

At present, about 20 similar monitors are installed - mainly at the "East-West" border. In 1998, a state programme has been elaborated in Belarus to provide all cross border points with CCRM equipment.

2. CONCEPTS OF CCRM REALIZATION

At present, a unique legislative basis was developed for CCRM in the Russian Federation. Russia begun the elaboration its own programme of CCRM within 1995-1996. In 1997, a "Guide for customs control of fissionable and radioactive materials" was elaborated and accepted. Nowadays, customs services are intensively equipped with appropriate devices.

At the beginning of 1998, Belarus as a member of the Customs Union also accepted its own "Principles of the customs control of radioactive substances" that are based on the above Guide. Other members of the Customs Union are going the same way.

Requirements to CCRM are based on the recommendations of IAEA, ICRP and also on the principles stated in "United automated State system of radiation situation control " accepted in Russia in 1996.

The documents of Belarus and the Russian Federation have some distinguishing features as compared to those of the other states. The main features are as follows:

- organization of specialized departments in the customs services: CCRM departments;
- strong regulation of the order of CCRM realization (including export control);
- elaboration of technical requirements to the equipment, including those of minimum detectable masses and activities;
- determination of a recommended list of appropriate devices.

Furthermore, a great attention is paid to the control of an illicit transportation of special nuclear materials. All the above resulted in the much more strict Russian and Belarussian requirements to the parameters of the equipment [2, 3] as compared to, e.g., requirements of the USA Standards [4-6] and the ITRAP programme of IAEA [7]. These may be seen from Table 1.

So, according to the Belarus and Russia documents, CCRM consists of some steps.

1. Initial CCRM. It is mainly carried out by fixed radiation monitors. These monitors operates in automatic mode and should have both the gamma and neutron detectors.

2. Additional CCRM. It involves the localization of sources that were detected by the fixed monitors.

3. Fundamental radiation inspection. It involves the identification of sources under field or laboratory conditions.

The radiation protection of the personnel is provided on each step.

Based on the said documents, the technical requirements to the CCRM equipment were elaborated.

3. EQUIPMENT FOR CCRM

It should be noted that the problem of elaborating the radiation control equipment was successfully solved during the creation of nuclear industry in the developed countries. The equipment is used as component of the physical protection of facilities. The leading world companies produce fixed radiation monitors to control vehicles and pedestrians, various portable devices and personal dosimeters; a number of this equipment may be used to provide customs radiation control.

However, the experience of the Republic of Belarus and the Russian Federation shows that a specialized equipment should be elaborated for CCRM.

Such a specialized equipment is used in Belarus [8]. These devices have a high sensitivity, especially for special nuclear materials, the correlated technical characteristics and can solve tasks as follows:

1. **Alarm** when a radioactive source is found in the controlled area with detection of not only gamma sources but also of special nuclear materials including those in a shield. The PM-5000, PM-5310 radiation monitors with gamma and neutron detectors are used for these purposes. So, the vehicle monitors PM-5000 detect up to 4.2.g of ^{239}Pu, 250 g of ^{235}U, and also 50 g of shielded ^{239}Pu.

2. **Localization** of the source is ensured by the alarming ratemeters and dosemeters PM-1401, PM-1402, PM-1703 (up to 2 g of ^{239}Pu at 1.5 m). It should be noted that these devices may be used for secret detection of radioactive sources by officers of special services.

3. Fast **identification** to determine the type of the source (natural radionuclide, artificial isotope, special nuclear material, etc.), to evaluate the alpha- and beta-contamination of surfaces, to record and store gamma-spectra and searching for neutron sources. The survey meter-spectrometers PM-1501, PM-1402 are used to solve this task.

4. **Radiation protection** of personnel of customs services. A family of personal dosimeters PM-1203, PM-1603, PM-1620 provide this protection. Note that personal dosemeter PM-1620 provides also a protection of customs officers who carry out luggage checking using X-ray equipment.

It should be pointed out that most of devices have a non-volatile memory to store automatically the information about the current events - alarms when detecting sources, background, sharp increase of the dose rate, dose levels, etc. The information stored may be then transferred to PC through the RS-port or IR-interface. These features enable an objective control that is not dependent on mistakes and unauthorized actions of personnel using these devices.

Thus, the Republic of Belarus has both the legislative basis and specialized equipment to provide an effective detection of an unauthorized traffic of radioactive materials. The realization of the State Programme of providing of all cross border points with CCRM equipment will ensure that nuclear smuggling across the "East-West" border will be practically stopped.

It should be pointed out that the same equipment may be used by personnel of special services to prevent unauthorized transportation of radioactive materials across the boundaries of various nuclear facilities, scrap processing plants, nuclear power plants, etc.

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Table 1.
Minimum detectable amounts of radioactive materials for vehicle radiation monitors

Radioactive material (radionuclide)	Equipment used in Russia and Belarus	Requirements of the ITRAP programme
^{137}Cs, μCi	10	270
^{239}Pu in the lead shield	50	300
^{239}Pu, g	4-10	-
^{235}U, g	250-1000	-

/

CHARACTERIZATION OF UNKNOWN OBJECTS CONTAINING RADIOACTIVE MATERIALS

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Abstract

Fraunhofer-INT is going to equip a transportable container with a system for the detection, identification and characterization of radioactive material inside objects with unknown content. This system will be a prototype for a mobile system to detect illicit trafficking of radioactive and especially nuclear material and will thus prohibit nuclear proliferation. This container will be equipped with systems for passive and active nondestructive measurements. For active measurements we use a sealed tube 14 MeV neutron generator with and without a moderating assembly between the interrogating neutron source and the object of interest. Because stolen or diverted radioactive material generally may not have a fixed geometry and will not be packaged in standard containers the main emphasis in this paper is on in-situ gamma measurements taking into account possible shielding around the radioactive source. High-resolution gamma measurements were performed on radioactive material behind different types of shielding. The measured data were evaluated by modeling the different parameters like the wall thickness of the box, matrix and shielding material inside and so on. Comparison with the actual experimental setup of the models showed good agreement and proved the power of this method. In this way significant information was gained on the content of the unknown box, which is important for further actions.

1. Introduction

To prohibit nuclear proliferation expertise and measurement systems must be provided to detect diverted or vagabonding nuclear materials quickly and with high significance. As pointed out by Dreicer et al. [1] various individuals, groups, and nations have a strong motivation to acquire weapons-useable nuclear material rather than to produce it because there is significant cost and time expense related to the development of the necessary infrastructure for production. So techniques for measurements of a varied range of materials and forms with the requirement to detect possibly shielded material rapid and in situ are needed [2]. A typical signature of nuclear material is their gamma and neutron radiation, but even more definite is the ability of this material to undergo fission when irradiated with neutrons of the proper energy.

For the nondestructive evaluation of the content of a suspect box we are going to set up a mobile system, mounted in a container, for the detection and identification of radioactive material and special nuclear material. This system comprises detectors for nuclear radiation and a neutron generator. Though gamma radiation from the radioactive material may be shielded with several centimeters of lead or tungsten, which makes measurements difficult to perform, information on the type and content of material may be gained in combination with theoretical calculations.

2. The transportable measurement system

The complete measurement system is transported inside a modified communication shelter with the dimensions 425 cm x 220 cm and a height of 208 cm [3]. The electric power supply is done by a diesel generator with a power of 25 kVA. In the air-conditioned shelter are working places for two people who perform the measurements and do a pre-evaluation of the data. The shelter can easily be transported on ground by a lorry and by air with a helicopter or an airplane. A communication system allows to transfer measurement data to an operation center where necessary decisions are to be made. A photograph of this container (shelter) is shown in figure 1.

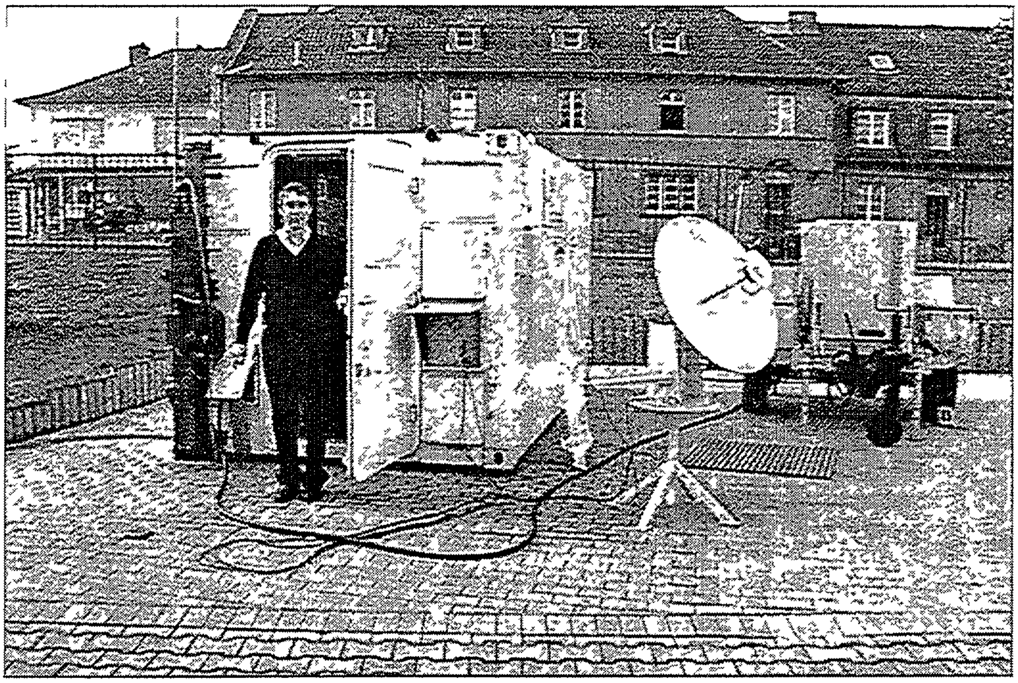

Fig. 1 Ground and air transportable container for detection and identification of special nuclear material

The measurement system consists of several detectors for gamma radiation, including a high resolution gamma spectrometer (which can be cooled electrically, too), and for the neutron detection moderated He-3 counters.

For high efficiency neutron detection we have several neutron slab counters at our disposal with the dimensions 23.4 x 51.6 x 9 cm^3. This size of the slab counters was chosen in order to have several practicable ways to configure all slab counters around the object of interest. The data acquisition is performed with a neutron coincidence analyzer such that coincidence neutron events can be separated from random neutron events. These coincidence neutron events are proportional to the number of neutrons from spontaneously fissioning isotopes or induced fission from fissile isotopes.

For active nondestructive measurements we use a 14 MeV neutron generator (d-T reaction) with an intensity of up to $2*10^8$ n/cm^2. It can be operated in a continuous or a pulsed mode. All parts of the neutron generator are fully transportable.

The detection of fission induced delayed neutrons gives a clear signal of the existence of special nuclear material. Additionally the absolute yields of the delayed neutrons as well as their yields as a function of the time after the neutron pulse vary significantly from fissionable isotope to isotope and thus constitute a clear signature [4].

A description of this transportable measurement system and some of its equipment for nuclear measurements is given in [5].

3. Gamma measurements on shielded sources

As already pointed out in the introduction (chapter 1) the radioactive material may be inside a box and surrounded by additional shielding material to obstruct detection and identification. Although the radioactive material may be shielded heavily by lead or tungsten in many cases it is still possible to identify the material by using appropriate simulation methods. The strategy hereby is similar to a try and error method. Various possible shielding geometries can be simulated in a short time. For each geometry the efficiency of the detector-shielding system is calculated. All efficiency calculations can then be used with the existing measurement. A likely shield geometry can be extracted by comparing the activity values determined by high energy lines and low energy lines.

3.1. The Gamma Measurement System

The ISOCS (In Situ Object Counting System) consists of a well characterized High Purity Germanium detector together with a shield system. The whole assembly is mounted on a cart (fig. 2).

A Monte-Carlo computer program is used to calculate the efficiency of the detector-source system [6]. A template e.g. for a box, a sphere or a pipe consisting of various source or absorption layers is used for the source geometry. The shield system is also included in the simulation. In combination with the detector characterization the efficiency for an assumed object geometry can be computed in a few seconds. By comparing the evaluation of the measurement with different efficiency curves, information on the most probable object configuration, source type and activity can be extracted.

The possible sample sizes range from sources as small as calibration sources up to contaminated soil within 50 m diameter.

Fig. 2 In Situ Object Counting System (ISOCS)

3.2 Measurements and Performance

The radioactive sample was placed in a distance of 100 cm from the front face of the Gamma detector. The detector was shielded with 25 mm of lead which reduces the interfering radiation outside the aperture of 30 degree by a factor of 7.5 (at 1000 keV) or even more for lower energies. For example two radioactive sources (Co-60 and Cs-137) have been set up 1 m from the detector and have been hidden by a 7.5 mm thick lead sheet. Several calibration files have been generated by the simulation code ISOCS varying the shielding thickness. The comparison showed a shielding thickness of 6 mm, that is a deviation of roughly 20 %.

4. Outlook and future efforts

To optimize the measurements we will perform studies with different object geometries. Because the geometry and form of the nuclear material as well as the surrounding material (box) is not fixed we will perform measurements using various setups with different size and composition. These measurements should be compiled in data files, so when measuring a box with unknown content a comparison can be made with the data taken in the laboratory. This will facilitate the identification.

This system is well suited for quick real time measurements in situ. Since it is fully transportable it can be used to detect illicit trafficking of nuclear material and thus contribute to prohibit nuclear proliferation.

Additionally this system may be used in future for treaty verification measurements on nuclear disarmament and transparency measures. It can be employed to detect diverted or vagabonding nuclear materials in situ quickly and with high significance. So this system may contribute to prohibit nuclear proliferation.

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GAMMA DETECTOR FOR USE WITH LUGGAGE X-RAY SYSTEMS

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Abstract

A new gamma radiation sensor has been designed for installation on several types of luggage x-ray machines and mobile x-ray vans operated by the U.S. Customs Service and the U.S. Department of State. The use of gamma detectors on x-ray machines imposed difficulties not usually encountered in the design of gamma detectors because the spectrum of scattered x-rays, which varied from machine to machine, extended to energies significantly higher than those of the low-energy isotopic emissions. In the original design, the lower level discriminator was raised above the x-ray end point energy resulting in the loss of the americium line associated with plutonium. This reduced the overall sensitivity to unshielded plutonium by a factor of approximately 100.

An improved method was subsequently developed wherein collimation was utilized in conjunction with a variable counting threshold to permit accommodation of differing conditions of x-ray scattering. This design has been shown to eliminate most of the problems due to x-ray scattering while still capturing the americium emissions. The overall sensitivity has remained quite high, though varying slightly from one model of x-ray machine to another, depending upon the x-ray scattering characteristics of each model.

1. System requirements

This gamma ray radiation detection system is intended to detect small amounts of radioactive material in luggage and parcels with a low false alarm rate. The system must operate in natural background and with the x-ray inspection system actively examining objects. Depending upon the operation of the x-ray machine the actual background due to x-ray scatter may significantly exceed the natural background rate. In addition, the length of time that a suspect package is actually within the field of view of the detector can be quite small as the package passes the detector while being loaded onto an x-ray machine conveyor belt. These constraints greatly complicated the selection of a detector and the design of the system.

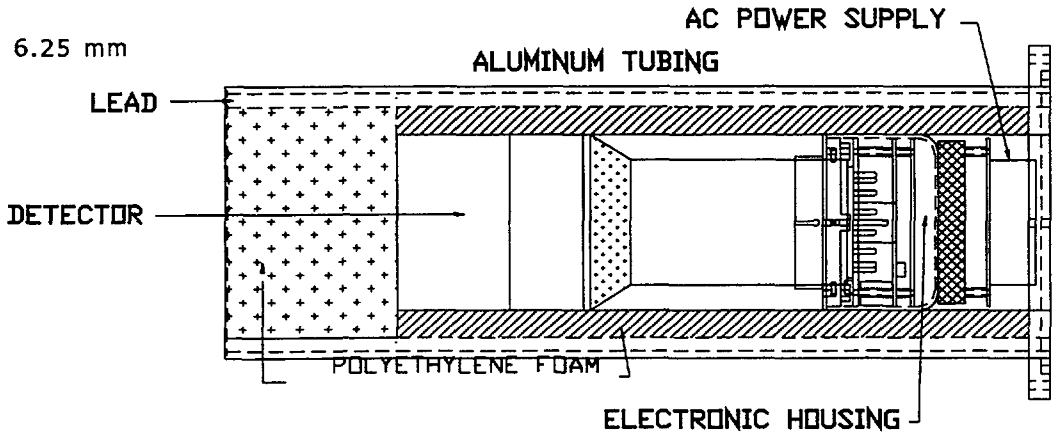
1.1. Luggage x-ray detector system

The first generation luggage x-ray detector system was based upon a 7.5-cm-diameter by 5-cm-thick NaI scintillator. The detector was housed in an enclosure lined with 6-mm-thick lead. This system readily met the sensitivity requirements. When this system was installed on x-ray machines, it was determined that x-ray scattering was generating high levels of erroneous or false alarms. A decision was made at that time to raise the energy threshold above the end point energy of the x-ray source (140 keV). When this was done, the false alarms disappeared but the unit could no longer detect the americium line from the plutonium decay chain (60 keV). The system could still detect the other higher energy gammas produced by plutonium, however, with reduced sensitivity.

The principal objective of the second generation luggage x-ray detector design was to enhance the original design to detect the 60 keV americium emission while operating in a moderate x-ray field. This problem was tackled on both electronic and mechanical fronts.

2. Mechanical design

Reduction of x-rays entering the detector was given the top priority in the new design effort. First, the detector shielding was increased to 6.25-mm-thick lead which reduced the 140 keV x-rays by greater than 99%. Next, a study was conducted to find the best method to minimize the field of view to that necessary to screen packages passing through the x-ray machine; excessive field of view presented a path for unwanted scattered x-rays to be picked up by the detector. Various collimator designs were tested using lead and steel assemblies placed over the detector face. The final design achieved the reduction in field of view by recessing the detector approximately 7 cm into the lead shield, creating a conical field of view of approximately 45 degrees from the centerline. Sensitivity was thus retained but the overall length of the instrument and the corresponding weight increased. A cross sectional drawing of the



detector and electronics is shown in Figure 1.

The effectiveness of this shielding/collimation scheme can be shown by comparing the natural background count rate of the detector without any shielding (250 counts/second) versus the count rate with the detector installed in the enclosure, 60 counts/second. Measurements taken at the entrance to some models of x-ray machines with an unshielded detector showed that the scattered x-ray count rate could occasionally exceed 20,000 counts/second. Using this enclosure design, the count rate due to scattered x-rays was reduced to a maximum of 240 counts/second on the worst case model of x-ray machine (see Table I). The actual scattering was a function of the relative positions of parcels being x-rayed and the position of the operators who were loading the parcels and includes natural background of 34 to 73 counts/second depending on the orientation of the collimator.

Table I. Gamma backgrounds for various luggage x-ray installations

System	Detector Background, counts per second

Van x-ray, including handler scatter	240 ±59
Luggage x-ray	164 ±10
Luggage x-ray, with added curtains	105 ±7.5
Pallet x-ray (preliminary)	205

The detector assembly is connected to an operator's control panel. The control panel is generally mounted near the x-ray machine keyboard. The detector is mounted near the entrance or exit of the x-ray machine at a height approximately 35 cm above the surface of the conveyor belt.

3. Electronic design

To handle the residual x-ray scatter that the shielding did not eliminate electronic methods were developed. Raising the energy threshold was unacceptable; the only other variable of opportunity was the count rate threshold. The count rate threshold on the most sensitive alarm level has been historically set at 8 sigma of the natural background to achieve a low false alarm rate. Upon application of power, the unit collects the background count rate and stores this value in memory. The true background in the x-ray machine environment consists of the natural background plus the x-ray scattering background. Since the x-ray scattering is a function of the particular x-ray machine, each machine type required a different value for x-ray scattering background. A 16 position switch whose setting was proportional to the x-ray scatter count rate was installed inside the operator's control panel. The setting of this switch was determined empirically for each type of x-ray machine. An attempt was made to determine the worst case scattering condition. The switch setting is designed to reflect the worst case scattering condition. This switch, which is set at installation, is read by the microprocessor immediately after power is applied. The microprocessor then adds this value to the natural background count rate and calculates the standard deviation of the total background. The lowest alarm level is then set to eight times the standard deviation of the total background rate.

4. Installation

The detector design proved robust in actual practice. However, to maintain maximum sensitivity, some additional modifications were found to be necessary. On van-type installations, it was determined that scattering into the detector could be significantly reduced by placing the detector at an angle of approximately 15 degrees to the axis of the vehicle (the x-ray emitter slit is aligned with the vehicle axis). The angular placement of the detector still provided adequate scanning operation while loading the conveyor. Lead curtains were installed on another model to greatly reduce scattering into the detector.

5. System alarm levels

Operator alarm levels are given in Table IV. Alarm level 9 has been adjusted to represent 4 mR/hr from Cs-137 at the entrance to the detector collimator. Alarm level 3 is approximately 15 microR/hr.

Table IV. System alarm levels

Alarm Level	Net Counts per Second (cps)
1	0
2	120
3	350
4	860
5	1350
6	3110
7	17680
8	28190
9	41340

6. Sensitivity data

Table II presents the measured sensitivity for various isotopes in terms of the net counting rates found in the laboratory at a distance of 60 cm to the scintillator face.

Table II. Gamma radiation sensitivity

Source Type	Sensitivity
Medical Isotopes	
^{111}In	63900 cps/mCi
^{201}Tl	38400 cps/mCi
^{99m}Tc	36800 cps/mCi
^{67}Ga	38900 cps/mCi
^{133}Xe	15500 cps/mCi
Industrial Isotopes	
^{241}Am	9230 cps/mCi
^{137}Cs	5310 cps/mCi
^{60}Co	5210 cps/mCi
^{237}Np	26700 cps/g
^{238}U	135 cps/g
Special Nuclear Material	
^{235}U	9.2 cps/g
^{239}Pu, 40 to 3000 keV	29017 cps/g
^{239}Pu, 70 to 3000 keV	190 cps/g

6.1 Comparison with first generation detector system

Table III shows that a significant improvement in plutonium detection sensitivity has been achieved with the new design.

Table III. Detection sensitivity for plutonium

System	Grams Pu-239	Grams Pu-239 Lead Shielded
First generation	1	5
Second generation	0.02	7

IAEA-CN-70/75

UTILISATION D'APPAREILS DE DETECTION POUR LUTTER CONTRE LE TRAFIC ILLICITE DE MATIERES RADIOACTIVES

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Abstract

Radiation detectors installed on fixed detection portals are widely used throughout the nuclear industry to prevent radioactive materials from being illegally removed from buildings or sites These cumbersome and expensive devices detect any abnormal increase in radioactivity levels at various points along routes used by personnel or vehicles It would therefore seem natural to use the same kind of equipment to prevent illicit trafficking of radioactive materials by installing it at strategic points We present the parameters which influence the detection of radioactive materials, taking a plutonium-239 source as an example, and show, in our study, how difficult it is to actually detect a radioactive substance The use of detectors used for real-time dose measurement is another interesting approach for the application These are small, inexpensive detectors worn permanently by personnel to signal any abnormal dose rates Although less sensitive than detection portals, they have a wider detection range than any fixed detectors, with a detection closer to the source

Resume

Les détecteurs de radioactivité installés dans des portiques de détection fixes sont utilisés couramment dans l'industrie nucléaire pour prévenir la sortie illicite de matières radioactives d'un bâtiment ou d'un site Ces installations lourdes et coûteuses détectent toute élévation anormale de la radioactivité aux points de passage du personnel ou des véhicules Il semble donc naturel d'utiliser ces mêmes matériels dans la lutte contre le trafic illicite de matières radioactives en les disposant à des postes stratégiques Nous présentons les paramètres influençant la détection de ces matières en prenant l'exemple d'une source de plutonium 239 et montrons par cette étude la difficulté réelle de détecter le passage d'une telle matière L'usage des détecteurs utilisés pour la mesure en temps réel de la dosimétrie est une autre approche intéressante pour cette application Il s'agit de petits détecteurs peu onéreux, portés en permanence par le personnel et qui signalent tout débit de dose anormal Si leur sensibilité est inférieure aux portiques de détection, ils permettent cependant de couvrir une zone de détection plus importante qu'une installation fixe, avec une détection au plus près de la matière

1. Portique de détection de matières radioactives

Les détecteurs de radioactivité sont utilisés couramment dans l'industrie nucléaire pour prévenir la sortie illicite de matières radioactives d'un bâtiment ou d'un site Installés dans des portiques de détection fixes, ils sont ainsi disposés aux points de passage du personnel ou des véhicules et détectent toute élévation anormale de la radioactivité

Dans ce contexte de surveillance de sortie de bâtiment ou de site, le choix et le réglage des détecteurs sont optimisés en fonction du type de rayonnement à détecter gros cristaux cylindriques de Iodure de Sodium (NaI) ou plaque de scintillateur organique pour la détection gamma et tubes à Hélium 3 pour la détection de neutrons Il semble donc naturel de vouloir utiliser ces mêmes matériels dans la lutte contre le trafic illicite de matières radioactives en les disposant à des postes stratégiques aéroports, routes, gares

Plusieurs questions se posent alors immédiatement à la personne chargée de choisir, d'installer et d'exploiter ces systemes Quels sont les matériels disponibles et les critères de choix ? Quelle est l'efficacité de ces systèmes et où doivent-ils être installés ? Combien cela va-t-il coûter ? Quelle formation doivent recevoir les utilisateurs ? Certaines de ces questions ont des réponses immédiates, comme le coût. D'autres dépendent de l'endroit à surveiller. L'efficacité d'un système de détection dépend par exemple fortement de l'ambiance radioactive.

2. Détection du plutonium

Nous présentons dans cette section les paramètres influençant la détection de matières radioactives en prenant l'exemple d'une source de plutonium 239. Pour une telle source, le nombre n de photons détectés à l'énergie E est une fonction de différents paramètres :

$$n = f_{source}(activité, c_{auto-absorption}) \times f_{detecteur}(efficacité) \times c_{ecran}$$

Le premier terme caractérise la source, le deuxième le détecteur et le troisième les écrans entre la source et le détecteur. Plusieurs hypothèses sont faites pour présenter les résultats qui suivent (modèle simplifié de calcul d'efficacité, d'angles solides ..), mais ils permettent cependant de donner des ordres de grandeurs intéressants

Influence du terme source

Considérons une source massique de ^{239}Pu de masse m = 2 kg avec les dimensions précisées figure 1.

Le nombre $n_0(E)$ de photons gamma émis par seconde et par gramme de Pu à l'énergie E est donné par $n_0(E) = I(E) \times a_0$ où I(E) est la probabilité d'émission d'un photon du ^{239}Pu à l'énergie E et a_0 est l'activité en Becquerel d'un gramme de ^{239}Pu. Le nombre de photons émis par seconde à l'énergie E dans la direction la plus pénalisante $\vec{u}$ est donné par $n_{\vec{u}}(E) = K(E) \times m \times n_0(E)$.

$K(E) = \frac{1 - e^{-\mu_{Pu}(E)x}}{\mu_{Pu}(E)x}$ est le coefficient d'auto-absorption.

Le tableau 1 donne les valeurs de $n_0(E)$ puis de $n_{\vec{u}}(E)$ pour certaines énergies d'émission caractéristique du ^{239}Pu.

Energie (keV)	13,6	38,69	51,62	94,66	98,44	111	129,3	375,02	413,69
I(E)(%)	4,4	0,00586	0,0208	0,00163	0,0029	0,0013	0,0062	0,00158	0,00151
$n_0(E)$ (pour 1 g)	1,01E+08	1,35E+05	4,78E+05	3,74E+04	6,66E+04	2,99E+04	1,42E+05	3,63E+04	3,47E+04
μ_{Pu} (cm^{-1})	2178	356,4	198	39,6	35,6	9,9	77	6,7	5,2
$n_{\vec{u}}(E)$ (pour 2 kg)	1,03E+07	8,39E+04	5,36E+05	2,10E+05	4,15E+05	6,70E+05	4,11E+05	1,20E+06	1,48E+06
Pu equivalent (g)	0,10	0,6	1	6	6	22	3	33	43

Tableau 1 : valeurs de $n_0(E)$ et de $n_{\vec{u}}(E)$

Seule une faible épaisseur du plutonium contribue à l'émission détectable. On peut traduire ceci en masse de ^{239}Pu « équivalent » pour lequel il n'y aurait pas d'auto-absorption. Cela montre clairement l'importance de ce phénomène pour le plutonium : le nombre de photons à 129,3 keV issu d'une source massive de deux kilogrammes de ^{239}Pu est le même que celui émis par 3 grammes d'un échantillon de ^{239}Pu qui ne présenterait pas d'auto-absorption (copeaux par exemple) !

Efficacité de détection

L'efficacité de détection ε est définie comme le rapport entre le nombre de photons détectés et le nombre de photons émis par la source. Elle dépend de l'efficacité intrinsèque ε_i du détecteur (rapport entre le nombre de photons détectés et le nombre de photons vus par le détecteur) et de l'angle solide Ω sous lequel la source voit le détecteur : $\varepsilon = \varepsilon_i \times \frac{\Omega}{4\pi}$. La figure 2 précise la géométrie de mesure étudiée.

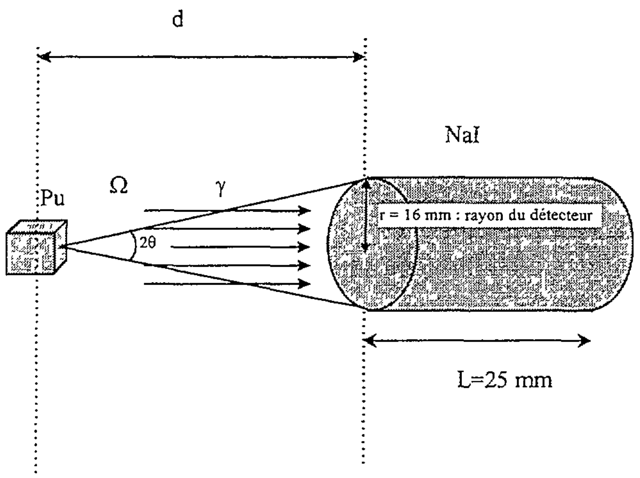

Figure 2 : géométrie de mesure

Nous donnons dans le tableau 2 les valeurs de ε_i obtenues pour un détecteur NaI de longueur 25 mm et de diamètre 16 mm.

Energie (keV)	13,6	38,69	51,62	94,66	98,44	111	129,3	375,02	413,69
ε_i	1	1	1	1	1	1	0,80	0,71	0,49

Tableau 2 : valeurs de ε_i obtenues pour un détecteur NaI

L'angle solide est donné par la formule : $\Omega = 2\pi(1-\cos\theta) = 2\pi(1-\frac{d}{\sqrt{d^2+r^2}})$

Application numérique :

1. d_1=40 cm $\varepsilon = \varepsilon_i \times 4 \times 10^{-4}$.
2. d_2=2 m $\varepsilon = \varepsilon_i \times 1{,}6 \times 10^{-5}$.

La distance d_1 est caractéristique d'un portique pour des piétons et la distance d_2 d'un portique pour des véhicules.

Influence des écrans

Le tableau 3 présente les épaisseurs de plomb nécessaires pour atténuer 90% et 99% des photons pour les différentes énergies considérées du ^{239}Pu, puis le facteur de transmission pour un écran de plomb d'épaisseur 8 mm.

Energie (keV)	13,6	38,69	51,62	94,66	98,44	111	129,3	375,02	413,69
Epaisseur (mm) atténuation 90%	0.02	0,2	0,3	0,4	0,4	0,5	0,8	8	12
Epaisseur (mm) atténuation 99%	0.04	0,4	0,7	0,9	0,9	1	1,5	18	22
t(8 mm de plomb)	<1E-10	<1E-10	<1E-10	<1E-10	<1E-10	<1E-10	<1E-10	0,08	0,11

Tableau 3 : influence d'un écran de plomb

Les émissions de faibles énergies du plutonium sont rapidement atténuées par le plomb.

Remarque :

La constitution d'une boîte de plomb ($\rho = 11{,}34\ g.cm^{-3}$) de 8 mm d'épaisseur permettant de contenir le lingot de plutonium aurait une masse de
$((2+0{,}8\times 2)(5{,}6+0{,}8\times 2)(9+0{,}8\times 2)-(5{,}6\times 9\times 2))\times 11{,}34 = 1{,}972\ kg$
Ce qui donne une masse totale de 4 kg pour un objet de dimension environ 11x7x4 cm^3 !

Prise en compte de tous les effets

Nous pouvons maintenant calculer le nombre de photons détectés en tenant compte des trois effets décrits précédemment. Nous prenons dans cet exemple un écran de plomb de 8 mm et considérons les deux distances d_1=40 cm et d_2 = 2 m. Le tableau 4 résume les résultats obtenus (nombre de photons n_1 et n_2) et montre le faible nombre de photons qui sera effectivement détecté.

Energie (keV)	13,6	38,69	51,62	94,66	98,44	111	129,3	375,02	413,69
$n_1(E)$ (d_1=40 cm)	4E-07	3E-09	2E-08	8E-09	2E-08	3E-08	1E-08	27,5	32,0
$n_2(E)$ (d_2=2 m)	2E-08	1E-10	9E-10	3E-10	7E-10	1E-09	5E-10	1,1	1,3

Tableau 4 : comptage détecté pour deux distances source-détecteur

Seuil d'alarme, limite de détection et probabilité de fausses alarmes

Le seuil d'alarme SA couramment utilisé dans les applications de détection de matières radioactives est défini par la formule $SA = Bdf + \sigma\sqrt{Bdf}$ où Bdf est le bruit de fond mesuré par le détecteur et σ un paramètre entier Un tel seuil est donc ajusté en permanence en fonction du bruit de fond radioactif relevé à l'endroit où se trouve le système de détection. Il est d'autant plus petit que le bruit de fond est faible La valeur de σ retenue fixe la probabilité de fausses alarmes. Pour $\sigma = 6$, on a par exemple $p = 10^{-11}$ soit moins d'une fausse alarme par an pour mille passages par jour dans le portique. En choisissant une valeur plus faible pour σ on diminue la limite de détection mais la valeur de p augmente.

3. Choix de systèmes de détection dans le contexte de la lutte contre le trafic illicite de matières nuclaires

Nous avons vu comment les portiques de détection de matières radioactives sont utilisés dans l'industrie nucléaire pour prévenir la sortie illicite de matières radioactives d'un bâtiment ou d'un site et nous avons étudié quelques paramètres permettant de caractériser ces systèmes. La conclusion principale à tirer de cette étude est la nécessité de connaître la source à détecter (forme physico-chimique, nature de l'emballage) pour choisir le système de détection convenable (nature et efficacité du détecteur, distance de mesure). Nous avons également montré qu'il n'est pas forcément aisé de détecter le passage d'une matière radioactive. Dans le contexte de la lutte contre le trafic illicite de ces matières, aucune de ces données n'est disponible !

Les portiques de détection sont d'autre part des installations lourdes et coûteuses qui doivent être installés à tous les points de passage obligés du personnel, des véhicules ou du matériel de l'installation à surveiller. Il ne semble alors pas envisageable d'équiper tous les points stratégiques concernés par le contexte de la lutte contre le trafic illicite de matières radioactives.

Une autre approche consiste à utiliser des systèmes « portables ». Nous pensons par exemple aux détecteurs utilisés pour la mesure en temps réel de la dosimétrie du personnel travaillant sur les sites nucléaires. Ce sont de petits détecteurs peu onéreux, qui signalent tout débit de dose anormal. Leur sensibilité est inférieure aux portiques de détection mais ils permettent de couvrir une zone de détection plus importante qu'une installation fixe . tout endroit où le personnel est susceptible de se rendre. La détection est alors possible au plus près de la matière et nous avons vu combien la distance entre la source et l'appareil de détection était un facteur essentiel pour augmenter l'efficacité de détection. Ces détecteurs sont enfin un outil utile pour la protection du personnel contre les rayonnements ils permettent de rassurer et de responsabiliser le personnel. Une solution possible serait alors d'utiliser conjointement des systèmes de détection fixes et des moyens portables.

La lutter contre le trafic illicite de matières radioactives n'est pas une tâche simple : il s'agit d'un ensemble de mesures et l'aspect « détection » qui étudié dans ce document n'en est qu'un élément. Il faut enfin rappeler que la sécurité des matières radioactives repose avant tout sur un suivi et une protection physique de ces matières à l'endroit même où elles sont détenues.

LE CONTROLE DE LA RADIOACTIVITE DES CHARGEMENTS DE VEHICULES (CRCV) DES CENTRES DU COMMISSARIAT A L'ENERGIE ATOMIQUE
Monitoring system for detection of radioactive materials in trucks at Commissariat à l'Energie Atomique (CEA - France)

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XA9848244

Abstract

Radiation Monitoring to control the radioactivity in vehicles and trucks are in use inside the sites of Commissariat à l'Energie Atomique.

The first function of these monitoring systems in the detection of radioactive source or contamined materials inside all loads of vehicles, before going out the nuclear site for the discharge of their materials either in a proper waste disposal or in an industrial site for material recycling. Other radioactive controls are conducted for nuclear materials and radioactive wastes.

The radiation monitoring system use 4 to 6 plastic scintillators mounted vertically on each side of the roadway near the truck and horizontally, above or below the vehicle. The functional components also include a microprocessor for processing the signals and algorithms for interpreting the data transmitted to the control unit. This system functions in a dynamic mode ; radiation is detected while the truck is in motion taking a series of incremental observations based on a differential countrate with the respect to the background. Vehicle scan information is printed out on a ticket specifying the result of the control.

In case of unexpected radiation, an alarm is emitted. The vehicle is submitted to further investigations to find the source with a hand held instrument, analyse the radionucleides by spectrometry and find its origin in order to manage the corrective actions.

The paper describes the system named « CRCV » (Contrôle de la Radioactivité des Chargements de Véhicules), *its sensitivity and the results of routine monitoring for several years. Few examples of radiation alarm are developed.*

Abstract

IMPLANTATION - DESCRIPTIF SOMMAIRE ET PERFORMANCES DES CRCV.

Des dispositifs de contrôle radiologique des chargements de véhicules (CRCV) sont en exploitation sur les centres du Commissariat à l'Energie Atomique.

La détection de la radioactivité se fait à l'aide de scintillateurs plastiques, au nombre de 4 à 6 implantés sur un portique. En cas de déclenchement d'alarme, des investigations complémentaires sont entreprises par les SPR (Service de Protection contre les Rayonnements) pour d'une part, identifier l'origine et la nature des radionucléides en cause et leur niveau d'activité et d'autre part, mettre en place les actions correctives.

Le principe de fonctionnement du CRCV et le logigramme des investigations complémentaires après déclenchement d'alarme sont communiqués sur les figues 1 et 2.

Les niveaux minimum de radioactivité détectables par les CRCV varient avec la nature des chargements, l'énergie des rayonnements gamma émis et la répartition de l'activité dans le véhicule, sachant que les émetteurs alpha et bêta purs sont contrôlés au niveau de l'installation par échantillonnage et analyse en laboratoire.

Pour un chargement de densité voisine de 1, l'activité minimale détectable est d'environ 0,1 MBq de césium-137 lorsque la source est en bordure du chargement et de l'ordre de 15 MBq si cette source est au centre du chargement.

Les performances s'établissent à 0,03 MBq et 3 MBq pour une source de Cobalt 60 placée respectivement en périphérie et au centre du chargement.

1. Role des CRCV

La fonction première des CRCV est le contrôle de tous les camions qui s'apprêtent à sortir du centre en vue d'une évacuation de leur chargement vers une filière ordinaire de gestion des déchets ou vers une entreprise de récupération de matériel. Le passage par les CRCV ne s'impose pas a priori pour les chargements de colis agréés à destination de l'ANDRA (Agence Nationale pour la gestion des Déchets Radioactifs).

Les CRCV sont également utilisés dans la gestion interne des déchets ou matériaux de chantier issus des zones contaminantes, pour effectuer une vérification et un tri éventuel avant de les entreposer sur site en attente de filières agréées pour les TFA (déchets de très faibles activités).

Lorsque le chargement des camions provient d'une installation ne contenant aucune zone contaminante, le CRCV constitue le seul niveau de contrôle avant les balises en sortie de centre.

Lorsque le chargement est issu d'une installation contenant des zones contaminantes, le CRCV correspond à un $3^{ème}$ niveau de contrôle. Il sert alors de vérification après le 1^{er} contrôle associé au tri, puis le $2^{ème}$ contrôle effectué en sortie d'installation, et constitue un dispositif de détection d'anomalies sur la gestion amont.

Le CRCV n'est pas le contrôle ultime puisque les sorties de centre sont équipées de balises qui ont pour fonction de surveiller tous les mouvements de matières radioactives. La sensibilité de ces balises est nettement moindre que celle des CRCV spécialement conçus pour le contrôle des déchets TFA.

2. Bilan des alarmes inattendues de presence de radioactivite.

La première mise en exploitation d'un portique de contrôle radiologique des chargements de véhicules a été effectuées à Grenoble en 1991. Les plus récentes installations, réalisées en 1996, sont celles de Fontenay-aux-Roses et Valduc.

Le retour d'expérience porte sur une exploitation des portiques de 2 à plus de 5 ans correspondant à un nombre de chargements contrôlés de 500 à 4000 par an et par site.

Un bilan sur la période 1995 - 1997 fait état de 20 à 30 dépassements annuels du seuil d'alarme pour l'ensemble des sites CEA, soit moins de 0,01% à 0,6% du total des contrôles suivant le site considéré.

Ce bilan ne concerne que les dépassements du seuil d'alarme provenant de chargements réputés non radioactifs comme ceux issus des zones non contaminantes.

Les événements radioactifs se partagent en deux classes :

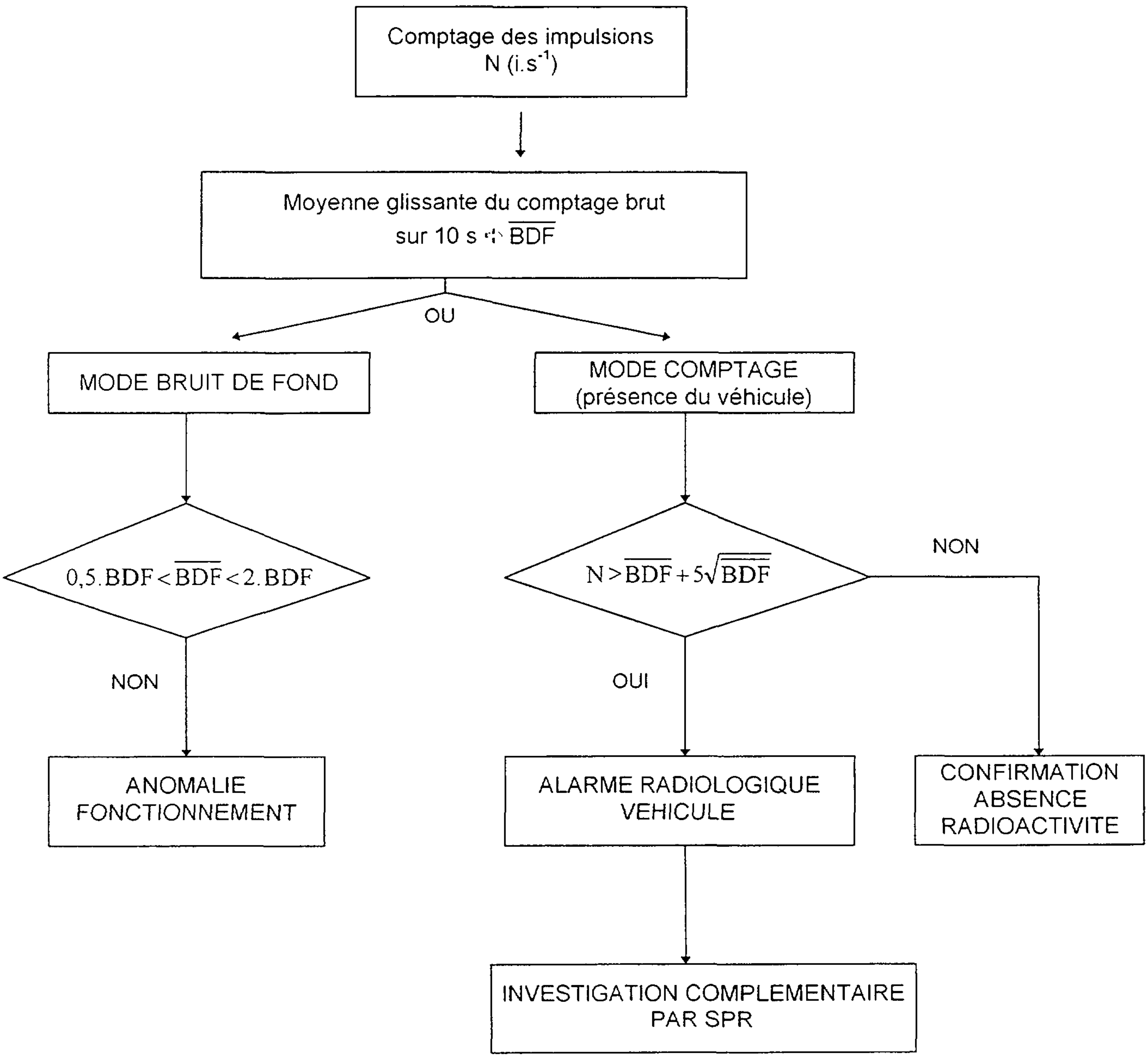
1) alarmes dues à la présence de radioactivité naturelle dans des matériaux manufacturés ou des échantillons de minerai,

2) alarmes dues à la présence de radioactivité artificielle, en distinguant les sous-classes suivantes :

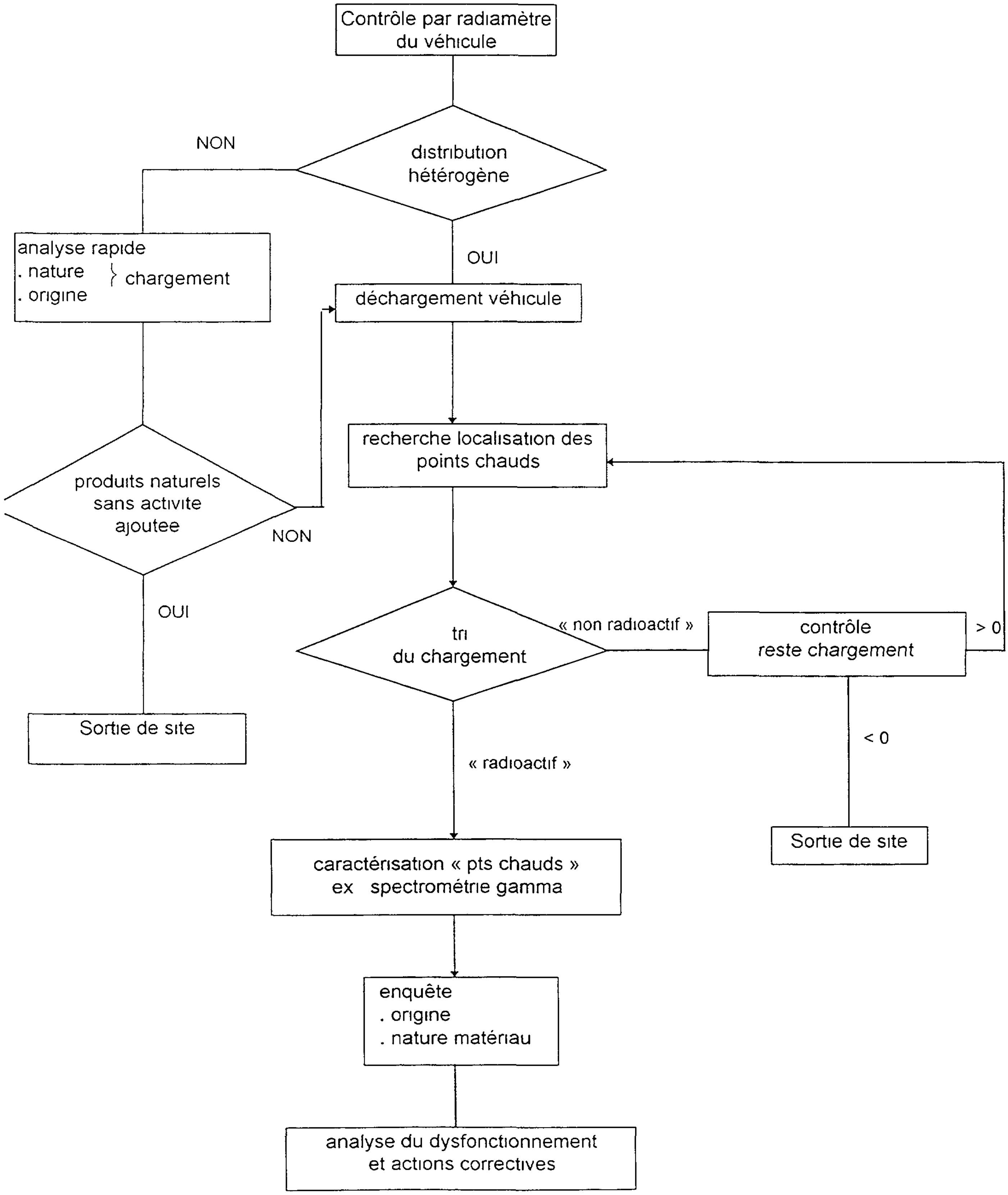
   a) présence normale mais non signalée de sources radioactives dans des appareillages tels que les détecteurs d'incendie, les matériels de mesure (chambre d'ionisation, ...),

   b) présence anormale de matériaux contaminés ou de sources radioactives.

PRINCIPE DE FONCTIONNEMENT DU DISPOSITIF DE CONTROLE DES VEHICULES



INVESTIGATION COMPLEMENTAIRE SUR CONTROLE POSITIF



EXEMPLES DE CONTROLES POSITIFS
- RADIOACTIVITE ARTIFICIELLE ET SOURCE -

nature produits	radionucléides	caractéristiques radioactives Activité, impulsions ou dose
Déchets « origine médicale »		
- déchets de soins contaminés - déchets liés à production de sources médicales	- $^{48}V + ^{46}Sc + ^{75}Se$ - $^{99m}Tc + ^{76}As$ - ^{64}Cu - ^{18}F	$A_t = 10^6$Bq (90% ^{48}V) T = 15 000 i s^{-1} T = 10 000 i s^{-1} 300 µGy h^{-1} 1 500 µGy h^{-1}
Déchets contaminés provenant d'installation nucléaire		
- harnais sécurité - outillage - tuyau ventilation - linge - gravats	^{60}Co $^{60}Co + ^{54}Mn + ^{125}Sb + ^{110m}Ag$ PF + PA ^{60}Co PF et PA	A = 4 10^{4}Bq A_t = 6 10^3 Bq (90% ^{60}Co) T = 300 i s^{-1} T = 200 i s^{-1}
Equipement de mesure (avec source interne)		
- appareils de dosage d'aérosols par ionisation	^{226}Ra	A = 10^5 à 10^{6}Bq
- chambre d'ionisation	^{137}Cs	A = 3 10^{5}Bq
Divers		
- marquage d'objet par peinture radioluminescente	^{226}Ra	peinture ^{226}Ra

EXEMPLES DE CONTROLES POSITIFS
- RADIOACTIVITE NATURELLE -

nature Matériaux	radionucléides	caractéristiques radioactives Activité, impulsions ou dose
Briques réfractaires	^{40}K, familles U et Th	1 à 1,5 Bq/g
Céramiques d'évier		0,5 Bq/g
Enrobé de chaussée (bitume - granit)		1,1 Bq/g (^{40}K = 0,8 Bq/g)
Isolants électriques		4 Bq/g
Engrais phosphatés		0,5 à 5 Bq/g
Echantillon de minerai d'uranium et autres minéraux	^{238}U et descendants	0,05 à 25 Bq/g (minerai U de 0,02 à 10%)
Nitrate de thorium (5kg)	^{232}Th + descendants	10^7 Bq

La répartition des alarmes, est la suivante à l'échelle du CEA,

➔ matériaux naturels et minerais : 10 à 50%

➔ radioactivité artificielle ajoutée et source radioactive :

.	matériaux contaminés par installation nucléaires :	20 à 35%
.	déchets d'origine médicale (production et soins médicaux) :	15 à 50%
.	source interne d'équipement de mesure ou de détection :	5 à 10%
.	divers :	10 à 20 %

Des exemples de dépassements de seuil d'alarme sont donnés dans les tableaux ci-joints.

PERFORMANCE TESTING OF AUTOMATIC VEHICLE RADIOACTIVE SOURCES MONITORS

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Abstract

The tests of the stationary devices for the detection of the radioactive sources in moving trucks were performed by the Czech Metrological Institute - Inspectorate for Ionising Radiation, Prague in December 1996 and September 1997. Ten different systems were installed and tested at a railway polygon. The basic part of each system - two detection units were placed symmetrically at the rail in a distance 2.3 m from the axe of the rail. The train comprising empty and scrap-filled trucks passed along the detection units at a speed of 5 to 30 km/h. The wide range of radioactive sources with ^{137}Cs (activity ranging from 0.4 MBq to 5 GBq) were located at different positions in the truck. The purpose was to determine a detection limit under different conditions. Sources with ^{57}Co, ^{60}Co, ^{241}Am were also used. The truck passed the polygon more then 1000 times. About 250 passes were free of source. All systems were also tested in a climatic chamber. The main features evaluated were the detection limit for an empty truck, detection limit for a truck filled with scrap (density 0.89 t/m^3), percentage of false alarms and stability of response to different temperatures. The other features like energy dependence, position dependence, linearity and overload, detection response time, etc., were also evaluated. The tested systems showing a positive result will be used in the field of steel recycling, metallurgy and the supervision of illegal transport.

1. Introduction

In recent years the number and seriousness of radioactive sources discovered in transported consignments, mainly scrap-metal has increased in the Czech Republic like in other countries. These sources constitute major health, technological, commercial and political risks.

Currently no universally accepted standard exists for automatic monitoring systems that stipulates the requirements and test conditions. Due to the complexity of the simulation of actual detection conditions, it is not possible for the individual users to test the systems. In the interest of compatibility of monitoring results, monitoring systems with sensitivity on the edge of technical possibilities are required at an acceptable price.

To secure the technical standards in the Czech Republic these systems are systems fall under state metrological inspection. The Czech Metrological Institute (CMI) performs this inspection.

The approval of types of stationery systems for the detection of radioactive sources in moving vehicles was performed by the CMI in two rounds, in December 1996 and September 1997.

2. Tested systems

Ten systems were submitted for approval of type. Below follow the name of the manufacturer, meter type markings and the detection principles used (PS = plastic scintillator, CsI = iodine caesium):

CETTO, type M2, 4xCsI;EBERLINE, type HT 1388, 2xPS; EMPOS, type EMS 2, 2xPS; EXPLORANIUM, type GR-526 /4400, 4xPS; EXPLORANIUM, type GR-526 /2200, 2xPS;

NE Technology, type NE ASM, 4xPS; RADOS, type RTM 910, 4xPS; SAPHYMO-PHY, type CTM 304, 2xPS; CHIRANA, type Y 911, 2xPS; MAB, type FZM 0700.003, 2xPS.

3. Test methods, resources, and conditions

A train was used in the dynamic tests. The test polygon constituted a 90-m long straight railway section. The train constituted a locomotive and two wagons with length of loading 12,80 m and width of load 2,76 m (type Eas). One of the wagons was empty; the second was loaded with 890 kg/m^3 of homogeneous milled railway buckles (clips).

The position of the radiation source was marked using four vertical steel pipes:

a) close to the end wall at the centre,
b) 70 cm from the side wall on the right, 320 cm from the first end wall,
c) at the geometrical centre of the loading area,
d) close to the second side wall, 320 cm from the second end wall.

The positions of the radiators (emitters) were 50, 100 and 150 cm from the bottom of the wagon. The basic testing position was c) /100 cm. The train moved at a speed of 5 to 30 km/h. For test purposes a set of 19 sources with radionuclide ^{137}Cs and an activity ranging from 0,65 MBq to 5000 MBq. Further ^{57}Co, ^{60}Co, ^{241}Am and ^{226}Ra radiators (emitters) with a predefined activity were used.

The detection units were installed along the line at 10-m intervals. The evaluations units were located in the control room.

The radiation background in the locality of the test polygon was on average 120 nSv/hr. The external temperature during the test period was in the range of - 3°C to +15°C and the following conditions had to be fulfilled: Minimum distance of 4600 mm between the detection units; setting of system before beginning of tests; prohibited use of modem or remote control; automatic operation of system and provision of the following information: detection of train passage, time, date, ALARM report and activity of source or NO ALARM.

More than 1000 passes were realised, 200 of which were without the test radiators (emitters).

The climatic tests were performed in a climatic chamber at the CMI. Only the detection unit was placed into the chamber. The frequency of impulses for the background and the response from the ^{137}Cs source in the temperature range of -25°C to +55°C were measured.

4. Scope and result of tests

1) The most important system features tested were the minimum detectable activity (MDA) and the
probability of false reports (FAP).The optimum system setting shows the least MDA at acceptable
FAP values. The requirement was FAP $\leq$ 0,5%.

MDA was defined for two extreme cases:

- MDA(F) - lowest activity of ^{137}Cs source in a basic test position in the wagon with the scrap metal was detected with a probability of more than 95 %.
- MDA(E) - defined in a manner similar to MDA(F), but for an empty wagon.

The MDA(F) and MDA(E) values determined are shown in Table Nr. 1 together with the FAP values ascertained. The values were determined by means of repeated train passes without any source of radiation. The margin of error for the MDA(F) and MDA(E) so determined was estimated at ± 30%.

2) The dependence of the system reaction on the activity of the sources expresses the ability of the system to provide primary information about the importance of the detection (the activity of the source). The dependence of ^{137}Cs sources with an activity ranging from MDA(F) to 1640 MBq located in metal-scrap wagons in the basic test position. Most of the systems showed the expected trend toward higher activity - greater response.
3) The energy dependence of the systems was tested using ^{57}Co, ^{60}Co, ^{137}Cs, ^{241}Am sources located in an empty wagon. All the systems showed the expected trend to higher energy - greater response.
4) The test of dependence of system response on the positioning of the ^{137}Cs emitters in the scrap-metal at positions b), c), d) and heights of 50, 100, 150 cm showed that the maximum relative effectiveness of detection is, on average, about 10x higher for radiators (emitters) positioned close to the wall of wagon as compared to the basic position.
5) All the systems burned-up during the tests of effectiveness of detection with radiators (emitters) positioned at the front of the train in the wagon with the scrap-metal.
6) All the systems burned up in the tests of the non-overload characteristics of the systems, that is, proper function with alarm message on passage of empty wagon with ^{137}Cs source with an activity of 5000 MBq located near the side wall of the wagon at a height of 100 cm.
7) The dependence of MDA(F) on the speed of the train in the range of 5 to 30 km/h and on the configuration of the train (the order of the empty wagon, loaded wagon with radiator (emitter) and the locomotive) were not confirmed by the tests. Only System Nr. 2 was functional only for a speed of up to 10 km/h.
8) All the systems burned up in temperature tests. The maximum change in the response to ^{137}Cs was less than 40 % of the responses at a temperature of 20°C.

5. Conclusions

A) Eight out of ten of the system types tested were approved. The system with CsI detectors was not approved on grounds of high MDA(F) and FAP values. One system with two plastic scintillators burned up as a result of high FAP value.
B) For most of the systems it is possible to derive the qualitative activity value from the response. Only System Nr. 3 had a practically constant response up to 500 MBq and System Nr. 2 up to 500 MBq this was less than MDA(F).
C) All the systems are capable of detecting gamma radiation with intensity $\geq$120 keV. For all systems the response increases with increasing gamma radiation.
D) All the systems burned up in non-overload and detection readiness tests.
E) The dependence of MDA(F) on the speed of the train(the exception was the system with the CsI detectors) and configuration of the train was not confirmed.
F) All the systems burned up in climatic resistance and stability tests.

Some of the systems were tested in Pennsylvania, USA [1] in October 1996 and the results are similar, despite the fact that different test resources and methods were used.

In view of the importance and high cost of the concerned systems and based on the current test experiences in the USA, Czech Republic and others, it can be recommended that international transport standards stipulating test requirements and methods prepared, for instance, within the framework of the IEC.

6. Reference

[1] Data Analysis, Steel Manufacturers Association, Test of Scrap Monitoring Systems; Koppel Steel, Koppel, PA; September 23 to October 4, 1996. Health Physics Associates, Inc.; June 1997

Table Nr. 1. The main parameters of the measuring systems tested.

Measuring system	MDA (F) [MBq]	MDA (E) [MBq]	FAP [%]
1	200	1	0.0
2	>1600	1	7.3
3	200	0.4	0.43
4	200	1	0.43
5	300	3	0.0
6	160	1	0.50
7*	50	0.2	13.0
8*	100	0.2	0.0
9	150	0.6	0.30
10	600	3	0.0
11	300	1	6.99

* The same system at various settings.

SOME INTERESTING FINDINGS FROM THE RADIOACTIVITY CONTROL OF TRUCKS AND WAGONS

dr. Mario Fabretto

XA9848246

1. Foreword

Monitoring of scrap imported into Italy from non-EU countries started in summer 1993, following directives issued by the italian Ministry of the Interior. Later, in 1995, this procedure was imposed by law (d.l. 230/95). After a short period during which only governmental structures were employed for field controls, very soon most of the work was transferred to private individuals or organizations, this mainly to guarantee the readiness required by steel-plants and transport services.

From that time on, several ten-thousands of vehicles were monitored, using different kinds of instruments, and some hundreds of radioactive sources inside scrap were spotted. This paper will briefly describe the used instrumentation, some statistics and how we found a ^{60}Co contamination on railway wagons' doors made in Czechoslovakia in the year 1990. Finally I will mention some other interesting cases occurred during routine monitoring.

2. Instrumentation

At the beginning two kind of instruments were used: a NaI 51x51 mm scintillator (Eberline ESP-2 with a SPA-3 probe) and a xenon proportional $\beta-\gamma$ laboratory contaminameter (Berthold mod. LB 123). Both resulted very effective in detecting even low increases over background radiation but they also evidenced major drawbacks: excessive weight in the case of the scintillator and an extreme fragility and moisture sensitivity in the case of the contaminameter. Moreover, both instruments allowed the operator to reach only as high as his straightened arm.

In the case of an important steel-plant in north-east Italy we were able to install an automatic scrap monitor (Exploranium, mod. GR 526-4004), but controls inside customs areas required to keep on with manual monitoring, making necessary to find more convenient instruments. The final choice had been a NaI 51x51 mm scintillator, contained inside a light carbon holder with an extensible support rod, connected to a waterproof data-logger. This system, specifically made for this monitoring purposes by Tema-Sinergie, resulted very effective both in detection sensibility as for handiness.

3. Statistic

From April 1996 until now more than 20.000 railway wagons have been monitored, plus some hundreds of trucks. Trucks carry mainly aluminum, copper, brass and stainless scrap, while less valuable scrap is usually brought by railway. From 1996 railway traffic has been recorded on a computer data base, allowing to derive some statistics. Figure 1 shows the monthly traffic and the number of vehicles, expressed as a percent of the total, for which a significative increment above background was measured. The sharp decrement of this number in 1996 is due to two concurring causes. The first was the performing, by some of the senders, of more accurate controls on the scrap before shipment: we contributed instructing and training some of them (f.e. training courses were organized in Hungary). The second cause derived by the understanding that, in many cases, the increased radiation levels were not due to the stuff inside wagon but to the wagon itself.

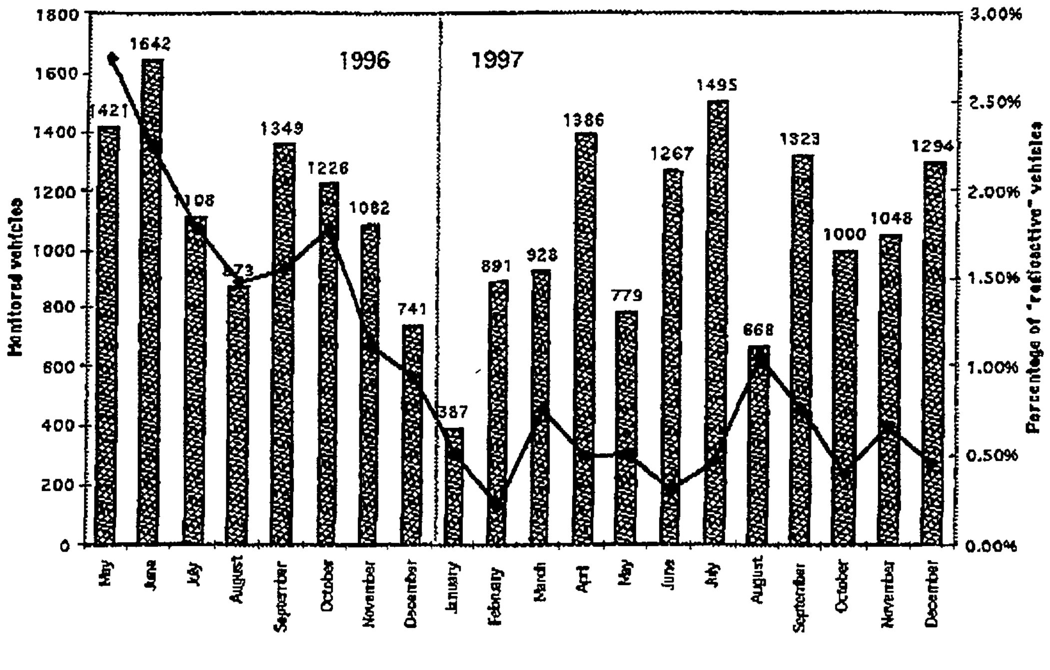

Figure 1 - Monthly traffic and percentage of vehicles containing a radioactive source.

In figure 2 measured intensities are reported versus time. Dose intensities are measured with a small compensated Geiger-Müller dosemeter (Perspective Scientific Ltd. RadAlert mod. 1201), very handy for carrying by the operator and provided by a very well designed software. In many cases a gamma spectroscopy with an NaI probe connected to a Silena SNIP spectrometer is performed. Most of the detected sources showed intensity below 0.5 μGy/h. Only few cases exceeded 1 μGy/h: the highest reached 190 μGy/h.

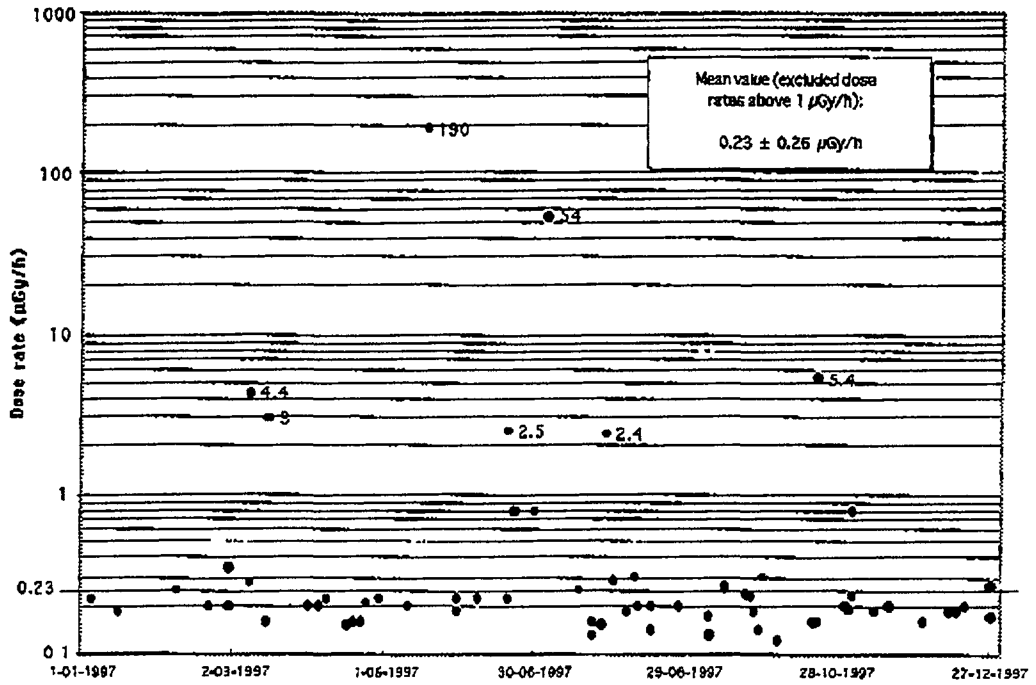

Figure 2 - Measured dose rates in 1997

Until the end of 1997 the number of controlled trucks was very low, so no collection of data was planned and we don't have the same possibility to show statistics for them.

4. Contaminated wagon doors

It was common knowledge among people involved in scrap monitoring that "the probability to find a source is higher near the wagon doors". This sort of "Murphy law" puzzled me and, watching closer, I realized that the counts increases were very similar from wagon to wagon. Further investigating, I found the following:

(a) counts were almost constant over the whole door surface;

(b) counts sharply decreased immediately away from the door;

(c) in some cases more than one door of the same wagon was interested by the phenomenon and the counts were almost the same on the different doors.

From the given radiation field, the solution of the inverse problem, i.e. to find the sources distribution producing it, was that of a plain homogeneous source; evidently the door itself.

When the first wagon containing pressed metal blocks instead of disordered material showed such a behavior, I asked the railway authority to allow me to open the door, verifying, in this way, the assumption.

Looking for other common characteristics it resulted that the contaminated doors were to be found only on one type of wagon produced in Czechoslovakia in the year 1990. Wagon of the same type have been seen with production dates ranging from 1983 to 1990. By recording the serial numbers of the wagons one could see that contaminated doors appear only on vehicles with a serial above 25590 (figure 3). The number of contaminated doors on the same wagon usually range from zero to four (out from eight present on the wagon), and it never happened to see more than four contaminated doors. Spectroscopy confirmed that contamination was due to ^{60}Co. Dose intensities measured close to the contaminated door surfaces range from 0.08 to 0.12 μGy/h, against background mean value of 0.06 $\pm$ 0.01 μGy/h.

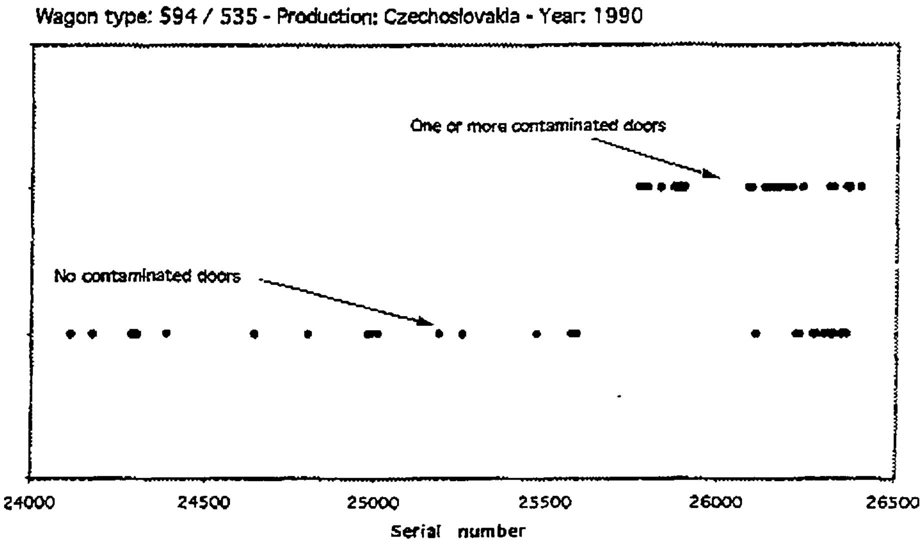

Figure 3 - Graphic representation of the distribution of contaminated vehicles versus serial number.

Because the problem wasn't at all relevant from the point of view of radioprotection, the existence of contaminated doors was communicated to those steel-plants using automatic scrap monitoring systems in order to avoid unnecessary rejections. The contamination finding was also notified to IAEA.

5. Other interesting cases

During routine monitoring of metal scrap some other sources were casually found among different materials. One case interested graphite electrodes: a dose intensity on wagon surface of 4.4 μGy/h was measured in 1997. Recently, in April 1998, a serious contamination was discovered on metal coils produced in Slovenia and imported into Italy: out of a wagon containing one contaminated coil a surface dose intensity of 0.2 μGy/h was measured, while a subsequent measurement of the dose in the empty space in the middle of the coil resulted in about 3.3 μGy/h. This last case was very probably the result of an accidental melting of a radioactive source.

Sometimes low increasing of radiation levels are detected in wagons containing metal turnings. Because of the mixed nature of this kind of stuff it is very difficult to estimate the level of the possible contamination. This could however suggest the possibility of contaminated final products.

A relatively high increase of background radiation was also detected near a truck carrying corundum. A radiation intensity about eight time background made our instruments switch to alarm mode. From a subsequent spectroscopic analysis performed at the Regional Center for Environmental Radiation Monitoring in Udine, it resulted that concentration of natural radioisotopes from uranium-thorium families exceeded the limit fixed by the italian law for non-radioactive materials (1 Bq/g). This result suggested to the interested firm the monitoring of radon concentration in working environments. Evaluations are still under development.

IAEA-CN-70/73

PREVENTION OF UNCONTROLLED DISSEMINATION OF RADIOACTIVE MATERIALS

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Abstract

The paper describes two radiation monitoring instruments, a radiation gate monitoring system (RGMS) with gamma (proportional counter) and neutron detectors and an environment radiation monitoring system (ERMS) with gamma (proportional counter) and aerosol detectors (filter measurement). While ERMS systems are operating in the Early Warning Network of Austria since many years, RGMS is presently under test.

1. Introduction:

A number of events involving contamination of the environment, overexposure, serious health effects, deathsof member of the Public have occurred over the past years. They resulted from radiation sources or radioactive releases that happened either inadvertently due to poor safety culture or intentionally due to illicit trafficking.

The june 1998 radioactive cloud that was released by the Algeciras Acerinox steel mill in Spain following the melting down of a Cs-137 radiation source is one recent example of the efforts which have to be made worldwide. Close control and timely detection are therefore essential to prevent any accident in the future.

The places where radioactive materials and radiation sources are located should be registered by the Public Authorities and any movement as well. The possible dissemination of any radioactive material (solid, liquid, gaseous) should be checked with appropriate measuring instruments at the fence of each facility and the borders of countries for early warning of the Public Authorities in order to promptly implement the necessary corrective actions (Emergency Plans).

2. Radiation gate monitoring system (rgms):

Objective: This system is meant to timely detect any kind of radioactive materials

1) at the fence of facilities such as mines, nuclear fuel fabrication, reactors for research, electricity production, ship propulsion, radiation sources for industrial and medical use, reprocessing of spent fuel, radioactive waste storage, radioactive installation being dismantled, etc.

2) at the borders of countries such as international airports, roads, railways and harbour check points.

Design: RGMS is designed according to a modular approach that can easily be adjusted to check persons, luggage, goods and vehicles (car, trucks, wagons). RGMS is built around two basic sensors, gamma and neutron.

The gamma detector is a proportional counter of 2 meters long with its associated electronics which is

capable of generating an alarm in 3 seconds as soon as the level of radioactivity is exceeding twice the level of the natural radioactive background.

The neutron detector is capable of generating an alarm in 1 second as soon as the neutron flux is equivalent to 300 g Plutonium source.

RGMS is fully automated and does not require any security officer in the vicinity.

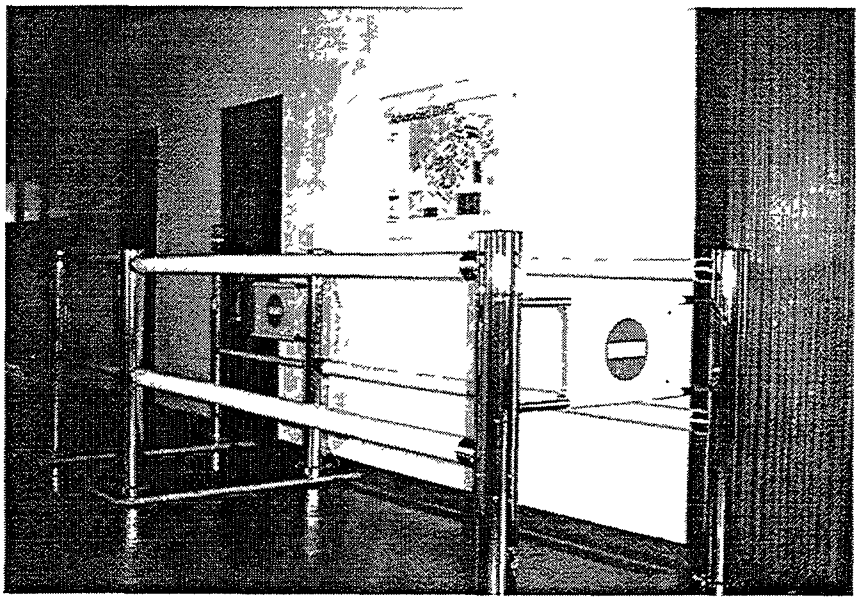
RGMS has been designed to look like an usual gate of department store and therefore cannot be identified as a measuring device for radioactivity.

RGMS can operate in a temperature range from minus 40 to plus 70 Degree Celsius and is not affected by water such as rain, snow, etc.

The supporting structure of the sensors can be built either in stainless steel or in aluminium, the gates "IN" and "OUT" as well. The instrumentation and control equipment and the control panel are based on highly reliable components meeting the most modern acceptance criteria.

RGMS for persons requires 2 sensors in horizontal position, for luggage 2 sensors, for goods and vehicles 4 to 8 sensors depending on the size of the vehicles to be checked.

Operation: RGMS, when not activated, has its gate "IN" open to accept a person, a luggage, a vehicle. When a person enters the corridor materialized by the sensors in horizontal position, the photocell closes the gate "IN" and starts the radioactive measurement. Three seconds later, if the measurement result is less than the threshold, the gate "OUT" is opened to let the person out, then the gate "OUT" is closed and the gate "IN" is opened to let the next person in. If the measurement result exceeds the threshold, an alarm is generated and the gate "OUT" remains closed. The security officer has to open the gate "OUT" from the control panel to terminate the sequence and to require a deeper radioactive measurement on the person and his hand luggage with a mobile monitor in order to identify the radioactive object carried by the person.



3. Environment radiation monitoring system (erms):

Objective: This system is meant to timely detect any kind of radioactive aerosols in the atmosphere and any increase of the gamma radiation level
1) at the fence of facilities in the vicinity of installations dealing with radioactive materials such as reactors for research, electricity production, ship propulsion, etc., reprocessing of spent fuel, waste treatment, waste storage, etc. (30 km zone)
2) at the borders of countries for early warning in case of accident with transboundary effects that might occur in the neighbouring countries.
The purpose is to assist in:

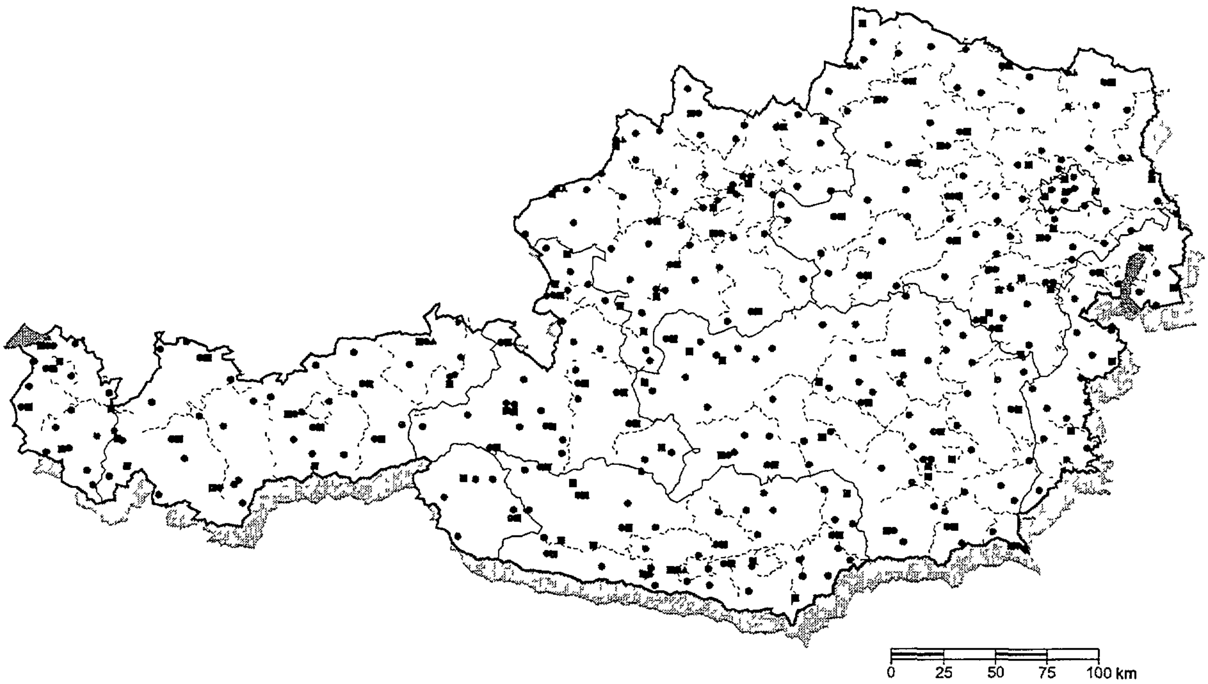
- implementing the National Emergency Plans to protect the Public by confinement, evacuation or other appropriate measures.
- providing information in compliance with the International Convention for Early Notification of Nuclear Accidents with Transboundary Effects.

Design: The ERMS built in Austria includes gamma detectors and an unlimited number of aerosol measuring stations (AMS). Each AMS has an extreme sensitivity and the highest reliability under the most severe operating conditions. The AMS are operated during several months without any close surveillance and are remote controlled by a central computerized station that performs the data analyses and generates the alarms for implementation of the National Emergency Plans.
AMS can operate in a temperature range from minus 30 to plus 40 Degree Celsius, and up to a relative humidity of 99 %.
Through the existing telecommunication network or a specific network devoted to the early warning of the Public Authorities, the information from the gamma detectors and the aerosol measuring stations is processed in the governmental centre on a 24 hours basis to promptly identify any unusual event.
Operation: The Aerosol Measuring Station is fully automated and served by a manipulator from a stock of 600 filters to count the radioactive aerosols with a routine measure of iodine, so that the non-natural radioactivity alpha, beta and gamma is taken into account. Filters can also be taken to

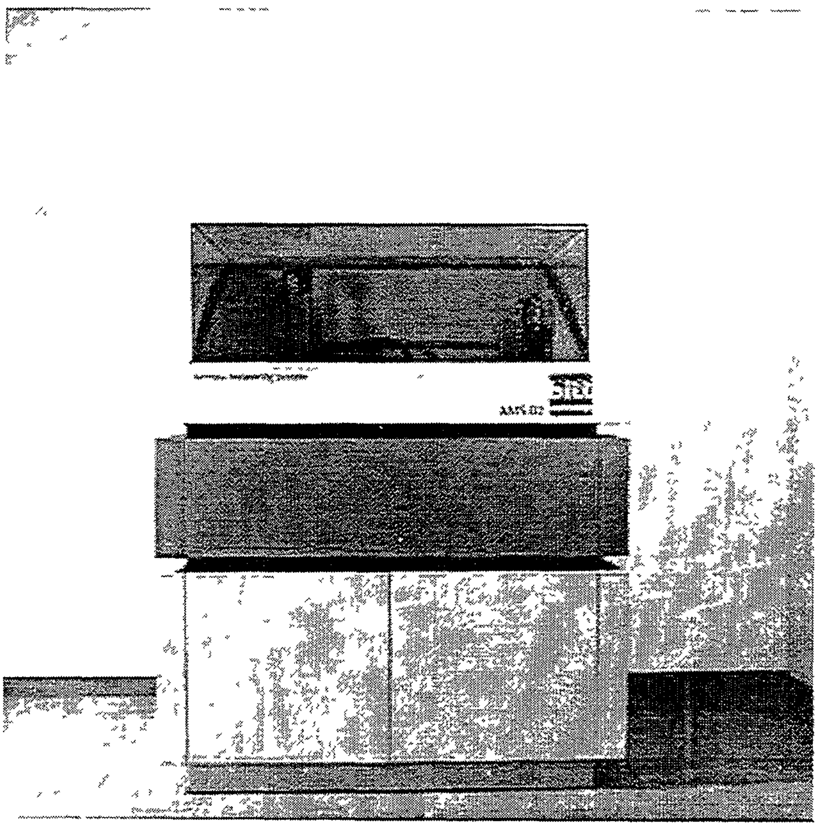
specialized laboratories to identify the specific isotopes involved. Under usual conditions, one suction cycle takes 24 hours for one filter. Measurements are carried out every 5 minutes. When an anomaly is confirmed on two measuring cycles, AMS is switched to the intensive mode (new filter, suction time 1 hour). The measuring evaluation enables an accurate qualitative and quantitative statement related to the alpha, beta, gamma nuclides.

THE AUSTRIAN EARLY WARNING SYSTEM

▲ AMS (Aerosol Measuring System)
● Gamma sensors



AEROSOL MEASURING STATION AMS 02



IAEA-CN-70/103

RANGERMASTER™: REAL-TIME PATTERN RECOGNITION SOFTWARE FOR IN-FIELD ANALYSIS OF RADIATION SOURCES

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Abstract

RangerMaster™ is the embedded firmware for Quantrad Sensor's integrated nuclear instrument package, the Ranger™. The Ranger™, which is both a gamma-ray and neutron detection system, was originally developed at Los Alamos National Laboratory for in situ surveys at the Plutonium Facility to confirm the presence of nuclear materials.[1] The new RangerMaster™ software expands the library of isotopes and simplifies the operation of the instrument by providing an "easy" mode suitable for untrained operators. The expanded library of the Ranger™ now includes medical isotopes ^{99}Tc, ^{201}Tl, ^{111}In, ^{67}Ga, ^{133}Xe, ^{103}Pa, and ^{131}I; industrial isotopes ^{241}Am, ^{57}Co, ^{133}Ba, ^{137}Cs, ^{40}K, ^{60}Co, ^{232}Th, ^{226}Ra, and ^{207}Bi; and nuclear materials ^{235}U, ^{238}U, ^{233}U, and ^{239}Pu. To accomplish isotopic identification, a simulated spectrum for each of the isotopes was generated using SYNTH.[2] The SYNTH spectra formed the basis for the knowledge-based expert system and selection of the regions of interest that are used in the pattern recognition system. The knowledge-based pattern recognition system was tested against actual spectra under field conditions.

1. Introduction

Quantrad Sensor, Inc. (QSI) licensed the Ranger™ technology from Los Alamos National Laboratory (LANL) in 1997. The Material Control and Accountability group at LANL uses the Ranger™ for *in situ* nuclear material (NM) confirmation measurements, medical isotope entry/exit confirmations, hand scanning, and shipper confirmations. QSI is developing new applications by adapting the LANL software to identify unknown isotopes for nuclear smuggling and other national security scenarios.

Initial efforts at Harvey Point (detailed below) expanded the existing LANL NM confirmation software to include more isotopes and a nontechnical display. After Harvey Point, QSI replaced the ruggedized detector (~10%) with a higher-resolution detector (7.5%) and developed a real-time pattern recognition system, RangerMaster™. As a basis for RangerMaster™, a spectrum for each isotope in the library was simulated with SYNTH. Careful analysis of the SYNTH spectra revealed that all the isotopes in the library could be identified with a unique set of regions of interest (ROIs). Initial validation of RangerMaster™ was done with the SYNTH spectra and the archived data from Harvey Point. Next, actual field tests were conducted at hospitals and the DOE Remote Sensing Laboratory (RSL) operated by Bechtel.

2. Background

The Ranger™ is an integrated detector system with a slightly moderated neutron detector composed of a matched pair of ^{3}He proportional counters and a 1-in.-diameter x 2-in.-long NaI(Tl) scintillator for gamma-ray detection. Neutron detection is provided for enhanced detection of plutonium. The gamma-ray multichannel analyzer has 256 channels. The MCA can be operated at full scale (6 keV/ch) or half scale for preset times or counts. The Ranger™ has two modes of operation: advanced and easy. The easy mode is a "point-and-click" isotopic identification tool, whereas the advanced mode is a full-featured MCA.

3. Harvey Point Demonstration

The first field test performed with the Ranger™ was at Harvey Point in May 1997, for the US Customs Service (USCS) in cooperation with the Department of State and Department of Energy (DOE) under the Radiation Detection Technology Assessment Program (RADTAP). In addition to background radiation, the assessment included the following isotopes: ^{241}Am, ^{57}Co, ^{133}Ba, ^{137}Cs, ^{60}Co, ^{232}Th, ^{40}K, ^{235}U, ^{238}U, ^{239}Pu, common medical isotopes, and ^{252}Cf. The assessment parameters included initialization time, calibration requirements, acquisition time, ability to categorize, documentation, size, ease of operation, user interface, alarms, display characteristics, battery, and robustness. The original LANL software was geared to *in situ* NM confirmation by technical personnel and was far from ideal for the USCS RADTAP.

Therefore, in April of 1997, QSI developed an expanded, nontechnical isotope identification algorithm for the Harvey Point demonstration based on the original LANL software. Far from optimal, each identification measurement required two spectra: one at half scale to resolve the low-energy lines of most medical isotopes and one at full scale to meet the full-scale energy requirements of the industrial and NM isotopes. This measurement requirement was due to the poor resolution of the ruggedized detector and the number of ADC channels. Each spectrum was limited to 30,000 counts. The actual analysis was a cumbersome set of "if-then" rules based on the net counts in predetermined ROIs to determine if an isotope was present.

Although the Ranger™ had high marks for many of the assessment parameters, the isotopic identification fared poorly, primarily because of insufficient statistics in the ROIs of the 30,000-count spectra. Obtaining sufficient statistics is a basic requirement to make a solid identification in any scenario. This requirement highlights an important aspect of in-field analysis by nontechnical personnel of unknown sources in an unknown geometry.

Review of the Harvey Point performance led QSI to make several changes. First, a higher-resolution gamma-ray detector was installed which eliminated the need to take two spectra and second, a knowledge-based pattern recognition system, RangerMaster™, was developed to replace the "if-then" rules. These changes resulted in a robust identification algorithm and increased flexibility in choosing termination methods. The data was archived and used later to validate the RangerMaster™ algorithms.

4. Simulated Data

To improve the identification algorithm, QSI worked with USCS to define a practical library of isotopes divided into three categories: nuclear materials (^{235}U, ^{238}U, ^{233}U, and ^{239}Pu), medical isotopes (^{99}Tc, ^{201}Tl, ^{111}In, ^{67}Ga, ^{133}Xe, ^{103}Pa, and ^{131}I), and industrial isotopes (^{241}Am, ^{57}Co, ^{133}Ba, ^{137}Cs, ^{40}K, ^{60}Co, ^{232}Th, ^{226}Ra, and ^{207}Bi). QSI simulated 30,000-count spectra for all of the above isotopes using SYNTH. The simulated spectra were examined and characteristic ROIs were carefully chosen to differentiate between the library isotopes. Since the LANL "if-then" code was not suitable for analyzing such a large number of ROIs, it was eliminated and a new knowledge-based pattern recognition system, RangerMaster™, was developed. RangerMaster™ successfully identified all the simulated spectra.

RangerMaster™ looks at each ROI for both a peak and significant net counts. It records the result in a feature vector that is examined by an algorithm for matches to isotopes included in the library. The significance (number of standard deviations, σ_{net}) of the net counts is an option that also can be varied. Additional isotopes can be added to the library as long as their characteristic pattern is unique.

The real-time in-field isotopic identification algorithm executes in less than a second. Depending on the source strength and measurement geometry, RangerMaster™ will identify the isotope in the minimum amount of time with a given statistical accuracy.

5. Harvey Point Revisited

The Harvey Point data was the first actual data used to validate the RangerMaster™ software. The data was read back into the Ranger™ and tested. The RangerMaster™ worked very well with this data despite the poor resolution and low total counts in the spectra. Of the archived spectra, RangerMaster™ correctly identified ^{235}U, ^{238}U, ^{239}Pu, and ^{137}Cs. It was not able to identify several very weak spectra (^{67}Ga, ^{60}Co, ^{238}U, ^{235}U, and a ^{252}Cf neutron spectra) that had inadequate statistics or were not in the library. Using only library isotopes and spectra with adequate statistics ($\sigma_{net} > 5$), RangerMaster™ identified 81%. Eight measurements did not meet statistical requirements and underscore the need for adaptive termination methods that work until identification is made or a reasonable amount of time elapses.

6. Medical Isotope Data

The second field test involved QSI personnel going to San Francisco-area hospitals and acquiring a number of spectra from medical isotopes with the 7.5% (FWHM@662 keV) detector at both full and half scale. These tests validated that RangerMaster™ was capable of identifying the medical isotopes using only the full scale. RangerMaster™ correctly identified ^{201}Tl, ^{131}I, ^{99}Tc, ^{111}In, ^{67}Ga, ^{133}Xe, and the industrial isotopes ^{57}Co, ^{133}Ba, ^{137}Cs, ^{60}Co, ^{238}U. It was not able to identify several spectra (^{22}Na and a mixed source of $^{201}Tl/^{111}In$) that were not in the library. Using only library isotopes and spectra with adequate count rates, RangerMaster™ identified 100% of the samples.

7. Remote Sensing Laboratory

Bechtel performed the third (and most comprehensive) test at the DOE RSL. This data was acquired with the 7.5%-resolution (FWHM@662 keV) detector. Three export files were generated by the RSL tests. The first export file consists of 16 runs of mostly medical isotopes. The second export file consists of mostly industrial isotopes. The third export file consists of plutonium and some industrial isotopes.

Bechtel chose to operate the Ranger™ in the preset time method and to vary the detection distance. Several sources were extremely hot. The Ranger™ needed only a few seconds to identify the source and continued collection allowed impurities in the medical isotopes to accumulate in noncharacteristic ROIs and confuse the pattern recognition system. The real-time nature of the Ranger™ allows for early termination if source strengths are substantial, as long as the statistical requirements are met. It is essential to take advantage of this feature when operating the Ranger™.

RSL Medical Isotopes

There are 16 spectra of 5 isotopes (^{99}Tc, ^{111}In, ^{201}Tl, ^{67}Ga, and ^{133}Xe) at different distances recorded here. Ten were identified correctly. All of the spectra could have been properly identified with proper measurement technique. For the Ranger™, proper measurement technique is defined as terminating the measurement when sufficient counts have been accumulated to allow RangerMaster™ to correctly identify the isotope in the minimum amount of time. RangerMaster™ had trouble with two isotopes because of the preset time termination method, ^{201}Tl being too hot and ^{133}Xe being too weak. Thallium-201 was correctly identified once and misidentified three times because of a relatively weak impurity that caused an unexplained doublet in the ^{239}Pu ROI. At 4 ft., ^{201}Tl was properly identified with 10% deadtime and a total of 60,000 counts. The misidentifications occurred at 1 ft. and 2 ft. with deadtimes of 64% and 25% and total counts of 305,848 and 194,344. Had the measurements been terminated earlier the doublet would not have grown to significant proportions. Xenon-133 failed because of insufficient statistics. Slightly longer collection times would have allowed RangerMaster™ to identify this isotope. Excluding the spectra that were obtained through improper measurement technique, the performance was 100%.

RSL Industrial Isotopes

Of the 24 spectra of 7 isotopes (^{232}Th, ^{226}Ra, ^{60}Co, ^{137}Cs, ^{133}Ba, ^{241}Am, and ^{57}Co) taken here, 11 were identified correctly. Of the improperly identified spectra, eight had low count rates, five had low statistics in a required ROI, and one looked like a $^{133}Ba/^{137}Cs$ source masquerading as ^{131}I. The low-count-rate spectra could have been identified with proper measurement technique (i.e., allowing the Ranger™ more time to collect adequate statistics). The low statistic spectra had an adequate count rate (>128 cps) but the total counts were low (<50,000), thereby causing at least one required ROI to fall short of being identified. Terminating on preset time did not allow enough statistics to accumulate to make an identification based on $\sigma_{net} > 5$. Excluding the spectra that were obtained through improper measurement technique and assuming the $^{133}Ba/^{137}Cs$ source was meant to simulate ^{131}I, then the performance was 100%.

RSL Plutonium

Of the 30 spectra of 7 isotopes (^{239}Pu, ^{111}In, ^{60}Co, ^{238}U, ^{133}Ba, ^{137}Cs, and ^{232}Th) taken here, 23 were identified correctly. Of the improperly identified spectra, five had low count rates and two had high count rates. The two high-count-rate spectra were ^{111}In that had high-energy tails due to impurities that created an significant edge in the ^{239}Pu ROI. With proper measurement technique this could be averted (i.e., allowing the Ranger™ to terminate collection based on statistics rather than preset time). The low-count-rate spectra could also have been identified if proper measurement technique had been employed. Excluding the spectra that were obtained through improper measurement technique, then the performance was 24 out of 24, or 100%.

8. Summary

All isotopes emit a unique gamma-ray signature. Low-resolution detectors, as are being used here, have limitations on their ability to discriminate between gamma rays of different energies. However, regardless of resolution, statistics play an important part in identifying radioisotopes. Many of the spectra taken here do not have the statistical foundation for a solid identification. The reason the proper statistics were not obtained is not clear. It is simply a basic requirement for good measurement technique and practice.

The Ranger was used to collect three data sets: Harvey Point, medical, and RSL. The identification software (version 1) for Harvey Point was adapted from existing LANL code and operated on data from a 10%-resolution detector. The identification software (version 2) for the medical data discarded the LANL code and implemented a pattern recognition system which operated on data from a 7.5%-resolution detector. The identification software (version 3) for the RSL data improved upon the pattern recognition system and once again used data from a 7.5%-resolution detector.

The Harvey Point data clearly show the error of terminating spectra at 30,000 total counts. This early termination was driven in part by needing two separate spectra at two gain settings due to the low-resolution detector and 256-channel ADC. However, by replaying that data with the knowledge-based pattern recognition system, the RangerMaster™ was able to correctly identify 81% of the isotopes.

For the medical data, it was assumed that there would be a lot of interference at the low energies (<200 keV), therefore the data was acquired at both the full (6 keV/ch) and half (3 keV/ch) scales. As hoped, RangerMaster™ identified 100% of the properly taken measurements at full scale, thereby eliminating the need for the half-scale measurements. This cleared the way for a broader range of termination schemes.

For the RSL data, all spectra were taken for a fixed time, 30 seconds, regardless of count rate and total statistics. This 30-second termination resulted in either weak spectra that the Ranger™ could not identify or misidentification of medical isotopes due to impurities showing up in noncharacteristic ROIs. Of the data with good statistics, the RangerMaster™ identified 100% of the time.

It is apparent that blind spectral analysis using low-resolution NaI(Tl) scintillators is difficult and must be controlled to achieve the best results. To do this, the measurement must first have good statistics (yet not take hours). The operator requires some positioning information that is simple yet adequate to take the guesswork out of locating the instrument for the best measurement. Also, the analysis must be completed in the minimum amount of time with adaptive termination methods that use a combination of time, counts and identification results.

9. Conclusion

The effective control of NM is paramount not only to professional NM managers, but also to US Customs agents, FBI agents, foreign customs agents, IAEA inspectors, and UNSCOM inspectors, to name a few. The threat of NM smuggling and the subsequent use of that material in a terrorist bomb has caused Congress to enact laws requiring that US borders be protected against the unauthorized introduction of radioactive material.

The average law enforcement officer is not faced with the classical NM safeguards scenario, but rather one of in-field radiation detection and isotopic identification to prevent the unauthorized use of NM. In-field radiation detection and isotopic identification differs from classical NM safeguards in a number of ways. Measurement geometry cannot be controlled; detection distances, measurement times, and intervening materials are all unknowns. Required operator training, knowledge, and understanding of physics is minimal. The Ranger™ provides a reasonable solution to the problem of in-field radiation analysis.

Until now, only highly trained nuclear spectroscopists had the tools to detect and identify radioactive sources used in medicine, industry, and nuclear power. The Ranger™ is a radiation detection system that provides isotopic identification in the field, for both the average law enforcement officer and the nuclear spectroscopist. The RangerMaster™ "easy" mode of operation reports the results of the analysis in simple, easy-to-understand language, while the "advanced" mode reports the details of the analysis and allows a spectroscopist to independently interpret the data.

9. References

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2. W. K. Hensley and E. A. Lepel, "SYNTH: A Gamma-Ray Spectrum Synthesizer," Pacific Northwest Laboratory document.

RESPONSE TO DETECTED CASES AND SEIZED RADIOACTIVE MATERIALS, STRENGTHENING OF THE AWARENESS, TRAINING, AND EXCHANGE OF INFORMATION

(Technical Session 10)

THE WCO/IAEA JOINT TRAINING PROGRAMMES FOR CUSTOMS SERVICES ON RADIOACTIVE MATERIAL SMUGGLING

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Abstract

One of the milestones of the WCO Enforcement Programme on Combating nuclear and other radioactive materials smuggling is to raise awareness among Customs services and reinforce their enforcement programmes by providing them training materials and training courses.

The International Atomic Energy Agency (IAEA) is recognized as a unique international organization in nuclear field to assist the WCO Secretariat by providing technical input in developing awareness/training materials and conducting training courses.

In line with their policies for the effective combating of nuclear and other radioactive materials smuggling, both international organizations have agreed to co-operate by regular attendance each other's technical meetings. This approach was formalized with the signing of Memorandum of Understanding on 13 May 1997.

The WCO and the IAEA training strategy has been to give priority to the Eastern and Central Europe region and the first joint training course was held in Vienna for Customs Trainers on 2-6 June 1997 and the second course is scheduled for Customs and Police officers of the same region in September 1998.

1. The WCO enforcement training module

The WCO has recently developed a Customs Enforcement Training Module on nuclear and other radioactive materials smuggling with the great assistance of certain Members and the IAEA experts.

The overall objective of this module is to provide Customs Training Units with a basis or framework to enable them to design their national training courses after modification if they desire. With the assistance of this module, national training courses could be conducted not only for beginners to provide basic awareness and knowledge but also for multi-agency courses to improve mutual understanding between Customs and other relevant agencies.

The target population in Customs services are recommended as "preventive, intelligence and investigation officers" who are dealing either with strategic import/export operations or cargo operation in general. However, due to the nature of radioactive materials, a note is particularly is added requesting that Customs has to co-operate with other competent law enforcement or regulatory agencies. In particular, a multi-agency approach should be adopted with regard to the gathering, development and exchange of relevant information, and the action to be taken after detection.

The module itself are composed of five main chapters: Introduction and Background, detection and Identification, Intelligence, response and awareness and Action.

Each chapters have its own separate objective, teaching points, suggested methods and trainers notes and finally evaluation sections.

The possible annexes for this training module will be quoted from the first joint training courses designed for Eastern and Central Europe region's Customs services.

THE WCO/IAEA JOINT REGIONAL "TRAIN-THE-TRAINER" PROGRAMME ON COMBATING THE SMUGGLING OF NUCLEAR MATERIAL, FOR CUSTOMS TRAINERS FROM EASTERN AND CENTRAL EUROPE

PROGRAMME

Monday 2 June 1997	Austrian Customs Training Centre

- Opening
- Problems and hazards caused by illicit movement of nuclear and radioactive material. The role of Customs services and the WCO in combating the smuggling of nuclear material.
- The IAEA Programme for combating the illicit traffic in nuclear and radioactive materials.
- Introduction of basic terms used in radioactivity and radiation safety.
- General properties and use of well-known nuclear and radioactive materials.
- Licit uses of nuclear material.
- Licit uses of radioactive material.
- General discussion.

Tuesday 3 June 1997	Austrian Customs Training Centre

- Radioactivity in scrap : Safety and economic problems for scrap recycling.
- High and low level nuclear and radioactive waste.
- Most frequently smuggled nuclear and radioactive materials.
- Regulation, packaging and labelling for the transport of radioactive and nuclear materials.
- IAEA video on transport regulations.
- Information sources at national level.
- Means and routes used for the illicit movement of nuclear and radioactive materials.
- Existing structures for the control of nuclear and radioactive materials.
- Radiation detection systems : General, technical and applications.
- General discussion.

Wednesday 4 June 1997 Austrian Seibersdorf Research Centre

- Radioactive response

- Field demonstrations and practical training

  - Detection of radioactive material in transport by low-level gamma monitors.
  - Identification of natural and technical radiation sources using energy selective methods.
  - Localization of radiation source in a car by means of portable instruments.
  - Detection and localization of radioactive material in the field.
  - Verification of labelling on a consignment.
  - How to check a package for removable contamination.

- Techniques for reducing the amount of in-depth examination, based on risk assessment.

- Possible indicators to help select consignments for further examination.

- General discussion.

Thursday 5 June 1997 Austrian Seibersdorf Research Centre

- How to control possible radiation hazards in practice.

- Practical demonstration on radiation safety.

- Health and safety procedures to be taken into account when encountering suspect consignments or substances.

- Follow-up of actions in the examination of a consignment.

- Procedures in the event of a damaged package or an accident.

- Principal procedures to be followed upon discovery of suspect material.

- Action to be taken after detection of illicitly moved nuclear material.

- Legal basis for the control of nuclear material.

Friday 6 June 1997 Austrian Customs Training Centre

- General discussion; revision and questions.

- Brief presentations by delegates.

- Distribution of certificates.

- Closing ceremony.

2. The WCO/IAEA joint training course :

2.1. The first joint training course

The WCO Secretariat, in co-operation with the International Atomic Energy Agency (IAEA) and the Austrian Seibersdorf Research Centre, organized a regional "train-the-trainer" programme on combating the smuggling of nuclear and other radioactive materials, for the benefit of Customs trainers from Eastern and Central European Customs administrations.

This training programme was designed as the first WCO training programme of its kind, based essentially on the draft WCO Enforcement Training Module on Nuclear Material in compliance with the decision taken at the Enforcement Committee's 16th Session.

The training programme was held in Vienna (Austria) from 2 to 6 June 1997, hosted by Austrian Customs and with financial support from Japanese Customs and the IAEA.

(31) participants from Customs Administrations of Albania, Austria, Belarus, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia and Turkey attended the training programme.

The trainers for the training programme were provided by the Customs Administrations of Germany, the United Kingdom and the United States, and also by the IAEA and the Austrian Seibersdorf Research Centre.

The training programme's overall objective was to assist the WCO Members in the region to use the WCO Enforcement Training Module on Nuclear Material (Doc. 39.750, Annex II, Part A) to prevent and detect the illicit transborder movement of nuclear and other radioactive materials.

The training programme consisted of two parts : theoretical and practical exercises. After two days of theoretical study, the participants were taken to the Austrian Research Centre for group and individual exercises on radiation monitoring and detection instruments for use on individuals, vehicles, passengers and baggage, as well as personal safety measures to be taken.

The programme schedule is reproduced at Annex I to this Report.

The participants received publications, posters, videos and documents for each teaching objective in the training module. They should now be able to design their own national training programme or to participate actively in existing national enforcement training efforts in this field. Furthermore, these publications and documents will serve as good reference material for the participants' work in implementing any short or long term training programmes to be designed for Customs inspectors in their home administrations.

After the completion of the daily training programme, a discussion panel was held with the participation of trainers. The overall objective of the discussion panels was to enable the participants to discuss some key points in detail, to exchange information and experience, and to improve bilateral and regional co-operation among the WCO Members in the region.

The Secretariat wishes to place on record its gratitude to Austrian Customs for hosting this important regional seminar, and to the Japanese Customs Administration and the IAEA for providing the funding necessary to make the training programme possible. The WCO Secretariat also expresses its gratitude to the IAEA and the Customs Services of Germany, the United Kingdom and the United States for releasing their staff as trainers for the programme.

The Secretariat also thanks the Austrian Seibersdorf Research Centre for its generous administrative and technical support, and for providing the services of experts.

2.2. The second joint training course

After the last year's successful training course, the WCO, ICPO/INTERPOL and the IAEA decided to conduct the similar training courses for the same regions' Customs and Police officers in order to continue their awareness activities as well as to improve the close co-operation not only between two national agencies but also in the whole region.

The programme will be financially supported by the IAEA and hosted by the Austrian Customs services in Vienna from 28 September to 2 October 1998.

3. Result

Bearing in mind that awareness raising and the training programmes are recognised an essential element in designing any action plan aiming at combating illegal movement of nuclear and other radioactive materials, the WCO, the IAEA the ICPO/INTERPOL are decided to meet Customs and Police services' requirement in this field. The sub-objective of multi-agency approach adopted by there international organization is to establish and promote the close co-operation between police and Customs services in order to derive maximum benefit from their limited sources and share experience with the establishment of contact points network.

IAEA-CN-70/11

LES CONSEQUENCES FINANCIERES DES DETECTIONS ET SAISIES DE PRODUITS RADIOACTIFS ILLICITES

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Résumé analytique

Le développement des trafics et des saisies de produits radioactifs illicites nécessite de prendre en compte leurs implications financières. Les bénéficiaires réels des trafics sont souvent difficilement identifiables. Les infracteurs sont généralement insolvables. Qui doit payer ? Comment recouvrer les frais de détection, d'analyse et de décontamination ? Une première solution serait de mieux responsabiliser les différents intervenants (détenteurs). Il pourrait également en être de même pour les complices des auteurs des infractions (transporteurs, entrepositaires etc...).

Une autre possibilité consisterait à appliquer le principe du pollueur-payeur.

Mots clefs

Coûts - insolvabilité - recouvrement forcé - douane - détenteur - pollueur payeur - consignation.

Le développement des trafics et des saisies de produits radioactifs illicites, nécessite d'analyser les conséquences financières qui en résultent pour les acteurs en charge de ces questions. Les incidences financières sont rarement posées comme préalable à l'action, en raison de l'urgence qui impose des moyens rapides d'intervention. La nature des risques encourus relègue donc souvent les conséquences financières à un second plan. Et pourtant, des sommes parfois très importantes sont en jeu. On peut notamment relever des frais d'intervention, d'analyse, de stockage, de décontamination, de réhabilitation de sites. Qui sont les responsables ? Qui doit payer ? Comment recouvrer ces sommes auprès de trafiquants souvent insolvables ? Comment éviter que ces frais soient imputés à des organismes spécialisés appelés à titre d'expert ? Autant de points qui nécessitent une réflexion dans un domaine où les règles habituelles de responsabilité sont parfois difficilement transposables dans le domaine des trafics illicites.

1. Remarques préliminaires

A l'issue des investigations menées par les différents services chargés des contrôles, il se trouve parfois que le responsable réel, initiateur du trafic, est souvent **difficilement identifiable.** Dans l'hypothèse où il le serait, il est souvent insolvable. De plus, il est difficile d'actionner des responsabilités au-delà des frontières.

En préalable à toute action administrative, il convient tout d'abord, d'analyser le risque réel lié à la protection sanitaire et aux exigences de sûreté, afin d'éviter la mise en jeu de sommes financières qui pourraient s'avérer ensuite démesurées par rapport aux risques réels encourus. Si les autorités compétentes ont diagnostiqué un risque important, la prescription des mesures techniques doit alors intégrer une évaluation financière.

La notion d'urgence est naturellement à prendre en compte pour déterminer le niveau de chiffrage des mesures à prendre. En fonction de cet impératif, différentes mesures de conservation pourront être prises. Les administrations douanières peuvent jouer un rôle particulier à ce premier niveau d'interventions (détection, immobilisation des moyens de transport, périmètre de sécurité etc...).

2. La recherche des responsabilités

S'agissant généralement de produits illicites transportés illégalement, à la suite de vols ou de détournement de destination privilégiée par exemple, il est difficile voir souvent impossible, de rechercher la responsabilité des principaux acteurs à l'origine de l'opération.

La recherche du détenteur pourrait s'inscrire dans ce processus. Cette notion de détenteur est en fait assez proche de celle de gardien d'une chose en droit privé. Ainsi, à défaut de pouvoir relever la responsabilité d'un propriétaire identifiable, il serait possible de rechercher qui avait la garde effective des produits illicites, au moment de la saisie. Il conviendrait alors, en l'absence de propriétaire ou de destinataire identifiable et solvable, de faire supporter sur le gardien de ces produits, une responsabilité sans faute, seul un cas de force majeure pouvant alors l'exonérer de cette responsabilité. Enfin, lorsqu'aucun responsable n'est identifiable, le recours à la responsabilité collective pourrait également être envisageable.

3. Autre solution : le principe du pollueur-payeur

Ce principe repose sur l'idée que tout pollueur doit supporter les coûts que la pollution est susceptible d'entraîner, depuis les mesures de prévention jusqu'à ceux des opérations de remise en état du milieu naturel auquel la pollution a porté atteinte. L'application de ce principe vise à faire supporter au pollueur le coût économique et financier de ces opérations. Les trafiquants de produits radioactifs illicites ne sauraient échapper à l'application de ce principe et bénéficier ainsi d'une dispense de réparation du dommage occasionné.

A titre général, ce principe a déjà été reconnu dans plusieurs textes et documents [1]

Dans le domaine des trafics illicites, des procédures de mise en demeure peuvent être prescrites à l'encontre des délinquants. A titre de garantie, des consignations sont souhaitables pour assurer le recouvrement des frais ultérieurs engagés. Les administrations douanières qui

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[1] Art. 130 R du Traité de Rome - Acte unique européen de 1986 - livre vert sur la réparation des dommages causés à l'environnement - loi française du 2 février 1995 sur le renforcement de la protection de l'environnement - AIEA - WCO/AIEA Technical Committee Meeting to develop Guidance Related to Illicit Trafficking - Draft Radiation Safety Guideline : Prevention, Detection of an Response to Illicit Trafficking in Radioactive Materials - Annex IX TC-1020.2 Working Paper n° 9 page 11, § 520.

ont souvent la qualité de comptable public, pourraient gérer ces procédures financières. Ces mesures peuvent porter, par exemple, sur les parties non contaminées saisies en connexité avec des produits illicites. La vente ultérieure de certains produits ayant un usage industriel pourrait ainsi être également un moyen de recouvrer les créances des organismes chargés des interventions et des expertises.

L'intégration des incidences financières dans les dispositifs destinés à lutter contre les trafics illicites pourrait contribuer à mieux responsabiliser les complices éventuels des trafiquants (transporteurs, entrepositaires, intermédiaires etc...).

L'application du principe du pollueur-payeur aux trafics de produits radioactifs illicites nécessite d'approfondir cette réflexion.

IAEA-CN-70/36

PROBLEMS AND MANAGEMENT OF RADIOACTIVE SOURCES AND MEASURES AGAINST ILLICIT TRAFFICKING OF NUCLEAR MATERIALS IN BULGARIA

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Abstract

Illicit trafficking of nuclear materials continues to pose a danger to public health and safety and to nuclear non proliferation efforts. The majority of cases so far have involved only small amounts of fissile materials or mainly radioactive sources in Bulgaria. A proper scheme for analysis of seized nuclear materials will be developed based on existing equipment for NDA analysis of nuclear materials supplemented by new system through PHARE project assistance by EU experts.

1. Introduction

The suitable geographical situation of Bulgaria on the crossroads between Europe and the Middle East puts it in the routes of different illegal traffics – jewels, drugs, arms etc. that have operated several decades.

During the last nine years after the big political and economical changes in the whole Eastern Europe there is a sharp increase in migration of people and goods in the Balkan region including Bulgaria. In the recent years however a new and hazardous traffic appeared on the surface – illicit trafficking of nuclear materials.

2. Status of radioactive sources and illicit traffic

In the period after the 60-ies a lot of nuclear sources were imported mainly from the former Soviet Union and applied in different fields of industry, agriculture, medicine, science etc. The lack of proper procedure for management, collection and disposal of spent sources especially the high radioactive sources resulted to the accumulation of great number of radioactive materials all over the country. The political and economical changes in the last seven – eight years led to reorganization in the industry – many companies and industry installations were shut down, people retired and in this manner at many plants the used radioactive sources had to be dismantled and disposed of.

The financial resources of the user however did not allow him to pay for the collection and disposal of the sources. In some cases the reduced control and administrative chaos led to theft and attempts for illicit trafficking of various radioactive sources – Co-60, Cs-137 sources, Ra ampoules, smoke detectors etc. Trafficant routes and connections were tested to organize channels for radioactive materials transfer in the country and across the borders.

The traffic of nuclear materials can be divided into two main parts - internal and transit.

The internal traffic includes the transportation of stolen nuclear materials or sources within the country mainly for personal profit. The stolen sources were mainly used in the industry as

- level meters
- dense meters
- devices for removing static electricity
- electronic balances
- smoke detectors etc.

Many of these are high radioactive sources whose transportation and handling needs special equipment and trained personnel. In most of the cases however, the illegal traffic of these nuclear materials is far outside the restrictions of the nuclear legislation in Bulgaria and is carried out by incompetent people who endanger their own health and subject innocent people to harmful doses.

Judging from the revealed by the police cases of illicit trafficking of nuclear materials so far the organizers are people with low qualification in the nuclear field trying to make profit and sell radioactive sources that are radioactive waste. In one case Plutonium capsules from smoke detectors were brought to a central hotel in Sofia to be sold to foreign citizens. In some of the cases the people involved in the trafficking have obtained substantial doses from outside irradiation.

The transit traffic of illicit nuclear materials is connected with the transfer mainly of raw materials from the former Soviet union and the Middle east towards Western Europe and vice versa. This traffic includes

- Plutonium
- Red mercury
- Osmium
- Scandium
- Cesium etc.

The Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences has established a collaboration with the responsible authorities from the Bulgarian police and Customs in handling and analyzing nuclear materials seized in illicit nuclear trafficking cases. The Institute possesses the necessary equipment - (Hot chambers, heavy shielded boxes, multichannel gamma spectrometry equipment with alpha and gamma detectors etc.) and trained personnel to perform the necessary analyses. The Institute also applies Atom absorption analysis and X-ray fluorescence analysis for qualitative and quantitative determination of the sample composition.

The detection and handling of both the internal and transit traffics raises serious problems to the controlling organs in Bulgaria both for equipment and qualified personnel at the borders of the country and inside.

3. Scheme for combating Illicit Trafficking

The first step in illicit nuclear trafficking after the seizure is the classical forensic at the crime scene accompanied by special precautions to avoid any danger. Specialists have to apply high resolution gamma spectroscopy to determine the composition of the nuclear material and indicate the category in which it falls (Weapon grade, weapon utilisable, nuclear fuel, radioactive sources with no fissile material etc.). This information is handed to the law enforcement to recognize the severity of the case.

In the second step the material is transported for further characterization in a specialized laboratory. All sample features that can reveal the intended use, age, origin and possibly, the smuggling route have to be measured. A variety of techniques have to be applied and if necessary foreign help can be included. To get best results the obtained results have to be compared to known materials, processes and specific environments so access to common (international) data base is necessary.

In the developing countries it is recommended that a proper scheme should be developed to combat illicit nuclear trafficking. First, it is necessary to identify and prioritize techniques and methods for forensic analysis to determine source attribution and intended use of the seized material. Next techniques and methods should be identified and prioritized for forensic analysis of non-nuclear materials to determine the geolocation and possible route. Then identification and evaluation of the available technical equipment for the initial hazard and preliminary assessment of nuclear material composition has to be done. After that supplement and improvement of the technical capabilities should be done as well as implementation of proper laws, protocols for collection and preservation of evidence etc. International cooperation and help is mostly needed in combating illicit nuclear trafficking.

It is also necessary to develop and apply such a system for control to eliminate the possibility of criminal loss of control on the radioactive sources, which will increase the safety of the sources and reduce the potential risk of accidents.

Raising the potential for the detection and identification abilities at the borders and inside the country is a task that stands in front of the state authorities in Bulgaria - Government, police, customs, licensing and controlling body - Committee on the Use of Atomic Energy for Peaceful Purposes etc. and this task has to find proper and competent solution. The interrelations between all the above authorities is also an important step in setting a barrier against all illicit all trafficking including the one with nuclear materials.

4. International collaboration

In Bulgaria a PHARE project is contracted for improvement by consulting and training the capacities for analysis of seized nuclear materials containing Uranium and Plutonium. Assistance will be provided by EU experts (Institute for Transuranium Elements ITU, Karlsruhe Germany) to improve analytical techniques for destructive analysis of seized vagabonding material and also organize intercomparisons of NDA measurements and equipment.

The exchange of technical experience related to illicit nuclear trafficking will improve the capacities of analysis of nuclear samples in Bulgaria and the option of assistance by destructive analysis of seized nuclear material in EU upon request from Bulgaria will be of great importance for the country's efforts to combat illicit nuclear trafficking in the line of nuclear non-proliferation.

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CONTROLE PAR LES AGENTS DES DOUANES DES SUBSTANCES RADIOACTIVES

Communication de Mme BEATRICE CAUSSE,
Administrateur civil, chef du bureau de l'organisation générale des services
à la direction générale des douanes et droits indirects

Résumé :

La douane intervient dans le cadre de la lutte contre les trafics illicites de substances radioactives en fonction de réglementations différentes selon qu'il s'agit de matières nucléaires, de radioéléments artificiels ou de déchets radioactifs. Faute d'uniformisation des bases d'intervention, les pouvoirs des agents des douanes sont souvent incomplets et difficiles à mettre en oeuvre. Dans le cas des produits contaminés par la radioactivité, il apparaît même que la douane n'est pas investie de pouvoirs directs et ne peut réaliser que des contrôles incidents.

Pour remplir au mieux sa mission de lutte contre les trafics illicites de substances radioactives, la douane a établi un partenariat avec le CEA qui compte notamment un volet de formation pratique et théorique destiné à renforcer les capacités de contrôle de ses agents.

Mots-clefs

formation - collaboration - matières nucléaires - substances radioactives - radioéléments artificiels - déchets radioactifs - pouvoirs des agents - contrôles - autorisation.

Ainsi que vous le savez, les problèmes relatifs aux contrôles des flux de substances radioactives ont beaucoup évolué depuis le début des années 1980. Avec l'accroissement des utilisations de la radioactivité et les enjeux économiques qui en découlent, en marge du simple contrôle des trafics licites, la douane a été amenée à prendre en compte l'existence de trafics illicites. Dans le même temps, la mise en place du GMI a considérablement bouleversé le contexte de ses interventions.

Compte tenu des risques connus, la France n'est pas un point d'entrée direct pour les trafics de substances radioactives, un premier rideau étant constitué par les contrôles effectués dans les pays de l'est, mais elle peut être une zone de transit.

Comme toutes les administrations communautaires, la douane a donc dû réfléchir à un renforcement de son action face aux risques accrus découlant des trafics de substances radioactives et notamment les risques d'introduction de déchets ou de produits contaminés.

Dans un contexte de pouvoirs limités, ce renforcement s'est concrétisé par la signature par le directeur général des douanes et l'administrateur général du CEA d'un protocole d'accord de collaboration qui a mis en place un véritable partenariat sur un certain nombre de domaines et notamment, en matière d'équipement et de formation aux contrôles mobiles. Désormais, il existe en la matière, une véritable expertise française.

1. Les pouvoirs des agents des douanes

1.1 Les pouvoirs des agents des douanes résultent :

- de la loi n° 80-572 du 25 juillet 1980, modifiée par la loi n° 89-454 du 30 juin 1989 relative à l'importation, l'exportation, la détention, le transfert, l'utilisation et le transport des matières nucléaires fusibles, fissiles ou fertiles ainsi que de toute matière, à l'exception des minerais, comportant une ou plusieurs de ces matières.

La disparition des formalités douanières pour les échanges réalisés entre les pays de l'Union, que les marchandises en soient originaires ou qu'elles aient été mises en libre pratique, réduit de fait la portée de ce texte aux seuls échanges en provenance ou à destination des pays tiers n'appartenant pas à l'Union européenne.

- *de la loi n° 75-633 du 15 juillet 1975 qui attribue aux agents des douanes des pouvoirs* de contrôle spécifique sur les flux de déchets radioactifs. Le dispositif a été adapté au Grand Marché Intérieur par la loi n°92-1477 du 31 décembre 1992 qui soumet à formalités particulières des marchandises sensibles de statut communautaire (originaires de la Communauté ou mises en libre pratique) lors de leur introduction ou de leur expédition en provenance ou vers un autre état membre. Cette loi s'applique par ailleurs aux radioéléments.

Le dispositif a été renforcé par le décret n° 94-853 du 22 septembre 1994 qui transcrit la directive 92/3 EURATOM du 3 février 1992 relative aux déchets radioactifs et qui instaure un régime homogène pour tous les flux : import/export, introduction/expédition, transit.

- s'agissant des *produits contaminés* (par exemple les ferrailles dont on a beaucoup parlé ces deux dernières années) et des radioéléments naturels, il existe un vide juridique. En effet, ces produits ne font pas l'objet d'une réglementation particulière en matière d'importation ou d'exportation. Ils ne peuvent donc être considérés comme prohibés. Dès lors, seule une infraction douanière ne concernant en aucune façon le caractère contaminé des produits, pourrait être constatée (fausse déclaration d'espèce, d'origine, de valeur, contrebande, importation ou exportation sans déclaration). Mais une telle infraction ne pourrait être constatée que dans le cas d'un échange avec les pays tiers, les agents des douanes ne disposant pas d'un pouvoir de contrôle général dans les échanges intracommunautaires.

De plus, leur saisie est conditionnée par l'existence d'une infraction douanière pouvant entraîner la confiscation par un juge. Un tel cas ne se présente que lorsqu'une importation ou exportation sans déclaration de marchandise prohibée ou une contrebande sont constatées.

De plus, les produits contaminés par la radioactivité n'entrent pas dans le champ d'application des lois de 1975 et 1980 précitées, ni dans le champ d'application de la loi n° 75-1335 du 31 décembre 1975 relative à la constatation et à la répression des infractions en matière de transports publics et privés. La seule possibilité pour les agents des douanes est la constatation d'une infraction à cette loi, uniquement lorsque la marchandise est contaminée par le moyen de transport lui-même, donc de manière incidente.

En outre, dans le cas où le vide juridique serait comblé, la douane aurait besoin, pour intervenir, d'indications précises quant aux seuils au-delà desquels elle pourrait et devrait agir. La transposition de la directive EURATOM n°96/29 du 13 mai 1996 pourrait offrir une occasion de combler ce vide, à la condition qu'elle ne concerne pas seulement les radioéléments et qu'elle comporte des clauses pratiques, applicables au contrôle douanier. En effet, le douanier, lors de son contrôle va mesurer un rayonnement. Il est nécessaire que soient définis des seuils de radioactivité au delà desquels il va immobiliser le chargement et prévenir l'autorité compétente. Le douanier, en situation de contrôle physique, ne peut pas apprécier l'intentionnalité de l'addition de substances radioactives, sauf à ce qu'un texte d'application définisse de manière objective comment distinguer des produits contaminés involontairement ou intentionnellement.

1.2 Dans ce cadre, coexistent deux types de contrôle :

- des contrôles de régularité fondés sur la présence des documents prévus par les textes.

En effet, les textes précités sont destinés à assurer la traçabilité et le contrôle de flux réguliers : ils reposent donc sur des mécanismes d'autorisation préalable et/ou de dépôt de déclarations auprès des autorités douanières. Dans ce cadre, les seules fraudes détectables portent sur :
- l'utilisation de faux documents
- l'utilisation de documents authentiques dans le cadre d'échanges illicites (fraude sur la nature du produit ou sa destination).

Dans ce dernier cas, c'est la comparaison des documents divers qui accompagnent la marchandise, l'origine du moyen de transport qui peuvent faire naître la suspicion des services douaniers et la saisine d'autres instances pour contrôles complémentaires.

- des contrôles destinés à détecter des flux illicites, circulant de manière totalement clandestine.

Ces contrôles ne font pas intervenir les mêmes services : plus que les bureaux de douane, ce sont les unités de surveillance qui sont le mieux à même d'identifier ces flux lors de leurs contrôles à la circulation, notamment lorsqu'il s'agit de marchandises ayant le statut communautaire.

Il est clair que, tant pour des raisons juridiques (principe de livre circulation au sein de l'Union) que pour des raisons pratiques (suppression des points fixes de contrôle), ces contrôles peuvent être systématiques. Dès lors, le renseignement (son acquisition, son traitement) joue un rôle fondamental dans le ciblage des moyens de transport à contrôler.

Le déroulement du contrôle lui même s'effectue selon une méthodologie spécifique dont la définition s'est effectuée en grande partie, grâce au partenariat conclu entre la Douane française et le CEA. La formation des agents est donc primordiale : elle constitue l'un des volets importants de la collaboration Douane/CEA.

2. La formation des agents

Conformément au protocole d'accord de collaboration signé le 3 juillet 1997 entre la DGDDI et le CEA,les experts du CEA participent à la formation des agents des douanes au contrôle des matières radioactives.

La formation accompagne la dotation des unités en matériels de détection et de radioprotection. Ces matériels qui ont été conçus pour la majeure partie d'entre eux par le CEA ont été choisis en raison de leur adaptation à des contrôles douaniers mobiles. Des radiamètres portables (DG5) sont destinés au contrôle rapproché et aux investigations, et permettent de localiser avec précision une source de rayonnement. Afin que la protection en temps réel des agents à l'égard des risques d'exposition qu'ils pourraient encourir soit assurée, ils sont équipés de dosimètres individuels électroniques (DMC100). Ces dosimètres possèdent des seuils d'alarme sonores réglables qui, fixés suffisamment bas, permettent d'assurer la sécurité du personnel.

Cette formation revêt un double aspect théorique et pratique. Elle est assurée par des équipes mixtes de douaniers et d'experts du CEA.

2.1 Aspects théoriques

La partie théorique porte tout d'abord sur la réglementation applicable, elle permet aux stagiaires de se faire préciser les points les plus complexes. Elle aborde ensuite les notions fondamentales sur la radioactivité (radioactivité naturelle, radioactivité artificielle), la mesure de la radioactivité (les différentes unités de mesure et leur signification), la protection contre les rayonnements, les notions d'irradiation et de contamination, puis la réglementation en vigueur sur la protection du public, ainsi que celle sur les matières radioactives et nucléaires, au vu des notions précédemment expliquées.

Cette séquence est l'occasion de présenter aux agents le danger nucléaire en faisant la part des risques véritables et des idées fausses, parfois reprises par les médias. La radioactivité naturelle fait également l'objet d'un exposé dans la mesure où sa connaissance permet d'éviter de fausses alertes. Enfin, le module s'achève par la présentation du fonctionnement du dispositif national d'alerte que les agents seront appelés à activer, en cas de constatation anormale.

2.2 Aspects pratiques

La partie pratique débute par la prise en main des équipements et par l'explication du maniement des appareils : installation des piles sur le DG5, mise en marche et mesure du bruit de fond, présentation des sonneries d'alarme et de la mesure de la radioactivité en coups par seconde. L'utilisation simultanée des DMC 100 et la démonstration concrète qu'une mesure de la radioactivité peut être effectuée au-dessous d'un certain seuil sans danger pour l'utilisateur du DG 5 est ensuite effectuée en présence de sources radioactives mises à disposition par le CEA.

Après la prise en main des équipements, débute une série d'exercices pratiques destinés à permettre aux agents d'acquérir la technique de radiodétection. Les exercices consistent en la localisation de sources radioactives en appartement, sur un tapis roulant, dans un garage, en extérieur sur un parking. La sensibilité des appareils de mesure a été montrée par le biais d'un exercice de contrôle embarqué (détection à partir d'une voiture roulant à faible allure dans un parking). La simulation d'un contrôle routier (contrôle documentaire, puis détection) permet de remémorer certains aspects de la réglementation des transports de matières dangereuses présentée le premier jour de stage.

Les différents exercices ont aussi offert aux agents la possibilité de comprendre, en pratique, les phénomènes de bruit de fond avec des alarmes se déclenchant dans certains contextes (près d'un mur, de sacs d'engrais ou d'objets en faïence) sans que cela témoigne pour autant d'un taux de radioactivité anormal. De la même manière, les différences de taux de radioactivité liés à l'environnement (par exemple, un sol granitique provoque un bruit de fond plus important) ont été expliqués.

Ces exercices sont pour les agents l'occasion de traduire en pratique l'instruction cadre mise au point par la DGDDI en collaboration avec le CEA. Les étapes des contrôles, à savoir, la localisation de l'origine de l'alarme, l'identification du véhicule ou de la marchandise, le contrôle documentaire sont présentées. Les agents apprennent à se positionner par rapport à la source du rayonnement radioactif et, en fonction du retentissement des alarmes, à respecter une distance suffisante pour ne pas prendre de risques inutiles et à établir un périmètre de sécurité.

A l'issue de la session, les agents sont en mesure de répercuter en cascade, dans les unités, le contenu de cette formation.

Conclusion

Depuis plusieurs années la douane fait d'importants efforts afin de lutter au mieux contre les trafics illicites de substances radioactives : équipement en matériels de contrôle, formation des agents. Dans un marché largement ouvert, la lutte contre la fraude menée sur la base d'un ciblage préalable et permanent des flux contrôlés ne peut aboutir sans un système d'information et de renseignement particulièrement performant.

C'est pourquoi, au delà du partenariat actif et fécond avec le CEA, la DGDDIest attachée à la mise en place de circuits efficaces d'échanges d'informations et de renseignements.

IAEA-CN-70/65

CONTROLE DES SOURCES RADIOACTIVES ET REGLES GENERALES EN CAS D'ACCIDENT

Lt SLIMANI Adel

For a long time now, radioactive accidents have raised the concern of all of their massive destruction and their large casualty potential. Yet with good organisation and with appropriate measures it is possible to reduce the risks and calm the worries.

The Tunisian O.N.P.C. put in place a concrete strategy made up essentially of 3 phases prevention, planning and intervention.

PREVENTION : In order to prevent radioactive accidents the Civil Protection conducts prevention studies on all radioactive sources by examining the normal conditions of use and the potential accidental situations.

PLANNING : It is about keeping up with the scientific, technical and statistical aspects of the radioactive risks. It's also the elaboration of specific plans and the programming of sequential intervention operations on one hand and the coordination and collaboration with the administrative and security services on the other hand and in serious cases with international assistance. Last but not least, the planning phase has to do with lightening the awareness of the population about the dangers involved and training the personnel.

INTERVENTION : The O.N.P.C. laid out a model intervention plan which is based on OBSERVATION (according to prelimary information) EVALUATION OF THE SITUATION (according to the head of the operation) INTERVENTION (specialized units) and POST INTERVENTION (Testing of personnel).

CONCLUSION : The tunisian civil protection, always faithful to its policers of autoprotection of all the citizens, and all the organisations will continue theirs missions in order to protect and act in all circonstances.

INTRODUCTION

Depuis longtemps les accidents radioactives à travers le monde sont l'objet d'une attention particulière du grand public et des médias , ils apparaissent en général comme insurmontables et sources d'une destruction massive des êtres vivants et de l'environnement, portant avec une bonne organisation et l'application de mesure de lutte appropriées il est possible de réduire considérablement cet impact et de minimiser ainsi les effets potentiels de l'accident .

Des mesures préventives semblable à celles organisées par la Protection Civile en collaboration avec les services spécialisés en radioprotection en Tunisie sont indispensables dans le but de réduire le risque , d'atténuer les inquiétudes et d'instruire le public sur les mesures de sécurités à observer en cas d'accident .

A - PREVENTION

Afin de prévenir les accidents radioactives , il est nécessaires de procéder pour toutes les sources une étude préventives au cours de laquelle sont examiner les conditions d'utilisation normale et les situations accidentelles previsibles.

1 - Législation Tunisienne

Le législateur Tunisien a promulgué des textes réglementaires relatif à la protection contre les dangers des sources de rayonnement ionisant qui assure la sûreté des sources de rayonnement et la sécurité des matière radioactives notamment :

-La loi n° 81-51 du 18 juin 1981 relative à la protection contre les dangers des sources de rayonnements ionisants.

- La loi n° 91-39 du 8 juin 1991 relative à la lutte contre les calamités à leur prévention et à l'organisation des secours.
- La n° 93 -121 du 27 décembre 1993 portant création de l'Office Nationale De La Protection Civile.
- Le decret n° 82-1389 du 27 Octobre 1982 portant organisation et attribution du centre national de radio-protection.
- Le decret n° 86 - 433 du 28 Mars 1986 relatif à la protection contre les rayonnements ionisants:
- Le decret n° 93-942 du 26 Avril 1993 fixant les modalités d'élaboration et d'application du plan national et des plans régionaux relatifs à la lutte contre les calamités à leur prévention et l'organisation des secours.

2 - Les organismes concernés

- Le centre national des sciences et technologies nucléaires est un établissement public à caractère industriel et commercial crée par la loi n° 93-115 du 22 novembre 1993 , il a pour mission de réaliser les études et recherches nucléaires a caractères pacifique dans les différents domaines , ainsi que la maîtrise des technologies nucléaires a caractère pacifique leur développement et leur utilisation aux fins du développement économique et social .

- Le centre national de radioprotection est un établissement public a caractère administratif , doté de la personnalité civile, placé sous la tutelle du ministère de la santé public , le centre national de radioprotection a pour mission de promouvoir a l'échelon national les mesures et les méthodes destinées à la protection contre les dangers des radiations ionisantes et de participer avec les service intéresses à l'élaboration et a l'exécution des programmes intéressant la radioprotection .

- L'Office National de la Protection Civile est un organisme qui relève du ministère de L'intérieur, son organisation et ses attributions sont régis par des textes réglementaires qui fixent notamment :

- Les missions de prévention et d'intervention
- La modalité de lutte contre les calamités et l'organisation des secours par l'élaboration du plan national et des plans régionaux (décret 93-942 du 26 Avril 1993) .

L'Office National de la Protection Civile prend tous les dispositions nécessaire pour signaler tout genre de risque notamment les risques inhérents au sources du rayonnement parmi ces mesures préventives .

- recenser les sources radioactifs en collaboration avec le centre national de radioprotection
- Instituer une surveillance physique pour déterminer la nature de précaution a prendre et élaborer les consignes générales et particulières.
- Etablir des plans d'interventions en la matières
- Former les personnels et cadres de l'Office National de la Protection Civile

B - PLANIFICATION DE L'INTERVENTION

Il est important lors de la mise en place d'un plan d'intervention d'urgence de bien définir un certain nombre de paramètre , d'un point de vue organisationnel une atténuation particulière doit - être portée à certains éléments

1 -La Planification

La Protection Civile a accordé une importance particulière à la planification:

- Le suivi des divers aspects scientifique , technique et statistique des risques radiologique
- L' élaboration des plans spécifiques
- La programmation séquentielles des opérations d'intervention en la matière

2 - Une collaboration avec tous les intervenants

L'organisation d'intervention est directement subordonnée au gouvernement (Ministre de l'intérieur) qui assume la coordination suprême de mesure de protection et de secours et oeuvre à renforcer les liens de coopérations avec les structures administratives , les entreprises et les services de sécurités compétents pour consolider les efforts tendant a atténuer les risques . Et face à un incident spécifique la Protection Civile ayant la responsabilité globale de la conduite des opérations en collaboration avec les services spécialisés en radio protection suivant le risque , la gravité de la menace , ainsi la sensibilité des ressources menacées d'ou la coordination.

3 - L'Assistance et la coopération internationale

L'assistance pouvait être demandée dans les situations très graves et dépassant les moyens nationaux , elle est proposée par les autorités responsables des risques radiologiques et décidée par le gouvernement à travers la voie diplomatique

4 - La formation et la mise à l'épreuve du matériel

La culture préventive se base principalement sur la sensibilisation et la formation du citoyen sur les risques encourus et les modalités pratiques pour y faire face rapidement et éfficacement par les différents moyens (mass-media, seminaire cible,...etc) . De temps en temps il sera souhaitable de mobiliser le matériels répertorié dans le plan de manière à le déployer pour tester son potentiel de disponibilité et de rendement .

C - LE DEROULEMENT TYPE D'UNE INTERVENTION

Vu les conséquences graves de ce type d'accident , il est indiqué de prévoir un schéma d'intervention comme suit :

1 - Observation

Les tous premiers renseignement concernant un accident radioactif peuvent être fournis par un certain nombre de sources , y compris le grand public, la police , la garde nationale et d'autre services d'urgences qui ont le numéro de tel , fax , fréquence radio leur permettant de contacter la protection civile chargé de la réception de ces renseignements .

La Protection Civile responsable des opérations est chargé d'émettre un compte rendu initial et de la transmettre aux parties intéresses ex: centre national de radioprotection

Un rapport initial devra faire partie du plan et contenir les renseignements suivant :

- Date et heure de la première observation
- position de la source (par un point repérable sur le terrain)
- source (type de source) et cause de l'incident si possible
- Estimation du danger
- Description de la zone
- Conditions météorologiques
- Action déjà entreprises et à entreprendre pour lutter contre l'incident
- Nom, profession , adresse, numéro de téléphone du témoin de l'accident

Un compte rendu initial sera transmis au plus vite aux autorités gouvernementales, précisant la situation et son éventuelle évolution.

2 - Evaluation

Le plan d'urgence doit prévoir une évaluation à effectuer par le commandant opérationnel sur zone (de la protection Civile) concernant la situation en cours , il devra également évaluer la menace posée par la source radioactif et les sites susceptible d'être contaminé .

Des mesures d'intervention devront être prises :

* Sauvetage
* Extinction
* Balisage (périmètre de sécurité)
* Collecte d'information concernant la source , ses caractéristiques et son activité ...

3 -L'intervention :

- Confirmation du périmètre de sécurité
- Mesures plus spécifiques
- Gestion des personnels, matériels , zone contaminée
- Liaison avec les organismes spécialisés
- Travail en zone contaminé
- Récupération de la source
- Bilan des expositions des premières secours

4 - Après l'intervention

- Lire les stylos dosimètre et relever les doses reçues par le personnel
- Contrôler le personnel , le matériel , les locaux et les véhicules
- Rédiger le rapport final.

D - CONCLUSION

La Protection Civile Tunisienne fidèle toujours à sa politique d'auto-protection de tous les citoyens , et de tous les organismes, continuera sa mission de sensibilisation et de vulgarisation à travers la mass -média afin de mener à bien sa tâche préventive et veillera à préparer , à protéger et agir en toute circonstance même avec des moyens limités.

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L'ORGANISATION DE CRISE DU COMMISSARIAT A L'ENERGIE ATOMIQUE POUR REPONDRE A UNE DEMANDE D'ASSISTANCE DES POUVOIRS PUBLICS.

J. PENNEROUX, Commissariat à l'Energie Atomique, France

Abstract :

In the frame of its obligations required by the state authority, the CEA has set up an organisation and intervention means for any needed assistance to responsible authority in case of radiological emergency.

In order to be able to answer to any assistance demand of a custom-house officer an agreement has also been found and signed between the French customs and the CEA for the control of radioactive materials and contaminated substances.

This paper presents the organisation set up by CEA to face critical conditions out of his own nuclear centers and specially in case of detection by the customs of unauthorized illicit domestic movement of radioactive materials.

Résumé :

Dans le cadre de ses obligations vis-à-vis des pouvoirs publics, le Commissariat à l'Energie Atomique (CEA) a mis en place une organisation et des moyens d'intervention lui permettant, à la demande d'une autorité responsable, de porter assistance, en cas d'urgence sur un événement à caractère radiologique.

C'est dans ce cadre qu'un protocole d'accord de collaboration a été signé entre la Direction Générale des douanes française et le CEA pour le contrôle des substances radioactives et des produits contaminés et répondre ainsi à toute demande des agents des douanes . L'exposé est consacré à la présentation de l'organisation de crise du CEA pour une assistance hors de ses sites et celle particulière à l'assistance aux douanes en cas de détection de substances radioactives circulant illégalement sur le territoire métropolitain.

1. Preambule

Face aux incidents ou aux accidents potentiellement radiologiques, les dispositions actuelles mises en place au CEA couvrent, d'une part la gestion de la crise qui traite de l'expertise de la situation et de son évolution, ainsi que de la communication externe, d'autre part l'intervention qui met en oeuvre des moyens opérationnels pour en limiter les conséquences radiologiques. Elles s'appuient sur des responsables identifiés, des moyens adaptés, et des procédures de veille et d'alerte.

En outre, des conventions ou des protocoles ont été signés par le CEA avec les autorités responsables et les organisations compétentes en matière de sûreté des installations, de protection des personnes et des biens, et de soins à donner aux victimes. Des conventions d'assistance mutuelle ont également été passées avec des entreprises du Groupe CEA-Industrie et d'autres exploitants nucléaires.

Les moyens CEA mis en oeuvre sont constitués par des centres d'expertise et de décision, ainsi que par des équipes mobiles d'intervention, des laboratoires d'analyse, des services médicaux, et des moyens techniques spécialisés. Des exercices internes, des exercices locaux ou nationaux permettent d'entraîner les personnels et de tester les procédures. Des actions régulières de formation sont menées au bénéfice des Unités compétentes appelées à intervenir.

Les objectifs visés sont, par ordre de priorité :

- de satisfaire les besoins propres du CEA qui doit assurer de façon efficace ses obligations d'exploitant nucléaire,
- de répondre aux demandes que les pouvoirs publics adressent au CEA dans un cadre contractuel ou réglementaire d'intervention,
- de répondre aux demandes des autres exploitants nucléaires dans le cadre des conventions mentionnées ci-dessus.

1.1. Missions

1 - <u>Les missions du CEA dans ses installations</u>

Le CEA est un exploitant d'installations nucléaires dont les statuts réglementaires et législatifs sont variés : Installations Nucléaires de Base (INB), Installations Classées pour la Protection de l'Environnement (ICPE), certaines d'entre elles pouvant présenter des contraintes pour la protection du secret de défense nationale.

Pour remplir les obligations qui en découlent, le CEA dispose d'une organisation de crise autonome en forte interaction avec celle des pouvoirs publics. Elle est destinée à la fois à mener l'expertise instantanée et prospective de la situation, à décider et à mettre en oeuvre les interventions, et à gérer la communication externe, tant au niveau local qu'au niveau national.

Par ailleurs, en application de la réglementation nationale, le Directeur de Centre ou le Chef d'Etablissement est le décideur en matière d'intervention sur le site dont il est responsable, ainsi que le représentant de l'exploitant vis-à-vis du Préfet.

2 - <u>Les missions du CEA hors de ses installations</u>

Trois directives interministérielles définissent les principes généraux de l'organisation nationale en cas d'incident ou d'accident concernant la sécurité nucléaire. Parmi eux, on peut citer en particulier :

- l'harmonisation des dispositions à retenir pour le risque nucléaire avec celles afférentes aux risques chimiques et biologiques,
- le développement de l'expertise et de l'information réciproques, d'une part entre les intervenants et les experts nucléaires, et d'autre part avec l'ensemble des acteurs concernés,
- l'importance capitale de l'information au sens le plus large,
- la clarification de la répartition des rôles entre tous les intervenants en situation d'urgence,
- l'intensification et la valorisation des exercices.

Ces directives concernent les administrations centrales des ministères impliqués, les Préfets de département ainsi que le CEA et l'IPSN.

Au niveau local, les Préfets sont responsables des décisions à prendre pour protéger les populations et pour permettre le fonctionnement des activités sociales et économiques. Les services préfectoraux, les services déconcentrés de l'Etat, les diverses administrations et les organisations professionnelles sont donc concernés par la gestion des situations d'urgence. Pour l'intervention immédiate sur le terrain, les Préfets s'appuient sur les services dont ils ont la responsabilité, notamment les Cellules Mobiles d'Intervention Radiologique (CMIR).

Dans ce cadre les situations de crise auxquelles peut être confronté le CEA sont diverses :

- ➢ incident ou accident sur un centre ou établissement du Groupe CEA,
- ➢ incident ou accident sur un site EDF,
- ➢ incident ou accident au cours d'un transport de matières radioactives,
- ➢ incident ou accident sur une arme nucléaire, sur site militaire ou au cours d'un transport,
- ➢ incident ou accident sur une chaufferie nucléaire embarquée à bord d'un navire de la Marine Nationale,
- ➢ incident ou accident dans un établissement public : hôpital, université, aéroport,
- ➢ incident ou accident dans un établissement ou lieu privé : sources industrielles, ...
- ➢ de terrorisme ou de malveillance.

1.2. Orientations

1 - <u>Orientations relatives au CEA exploitant</u>

Un plan d'urgence interne (PUI) est établi pour chaque établissement concerné par le risque radiologique. Outre les exercices prescrits par l'autorité de sûreté entraînant le déclenchement du PUI, les Directions des Centres et Etablissements CEA et les Directions des entreprises du Groupe CEA-Industrie implantées sur les sites CEA organisent régulièrement des exercices de sécurité n'entraînant pas le déclenchement du PUI.

Pour rendre ce dispositif plus performant, il convient de mettre l'accent sur :

- l'organisation d'exercices nationaux destinés à intensifier l'entraînement des personnels, à valider la répartition des rôles et les relations entre les centres de décision et ceux d'expertise, la mise en oeuvre des moyens et les procédures associées.
- la capitalisation au niveau central des enseignements tirés des situations d'urgence réelles ou simulées et la diffusion de ce retour d'expérience aux Centres ou Etablissements CEA.
- la tenue à jour des plans d'urgence interne.

2 - <u>Orientations relatives aux missions réglementaires du CEA</u>

a) La Direction Centrale de la Sécurité assure pour ces missions extérieures à ses sites, au nom et par délégation de l'Administrateur Général, la direction opérationnelle de l'ensemble des moyens du CEA, le CEA/Le Ripault étant chargé de la gestion logistique des équipes engagées.

b) Dans l'exercice de ces missions, le CEA place un **"conseiller technique d'intervention nucléaire"** auprès de l'autorité responsable de l'ensemble de l'intervention. Ce conseiller représente le CEA auprès de cette autorité : il la conseille sur l'emploi des moyens du CEA et sur leur intégration dans l'ensemble du dispositif opérationnel.

c) Les Unités concernées de l'Institut de Protection et de Sûreté Nucléaire (IPSN) participent à l'expertise, aux échanges de données relatives à la caractérisation des zones contaminées, aux actions de formation et aux exercices qui s'avèrent nécessaires ; pour les armes nucléaires, les conditions d'exercice de ce rôle d'expertise sont précisées en liaison avec les autorités militaires concernées.

2. Missions d'assistance du cea en cas d'evenement a caractere radiologique, ou potentiellement radiologique, survenant hors de ses etablissements.

Le CEA est doté d'une structure lui permettant de porter assistance, en cas d'urgence sur un d'événement à caractère radiologique ou potentiellement radiologique, à la demande de toute personne ou organisme extérieur lui en faisant la demande.

L'assistance du CEA peut se traduire, après accord de l'autorité responsable des secours, par l'intervention de moyens du CEA.

L'assistance du CEA a pour but de conseiller l'autorité responsable des secours, de réaliser un diagnostic radiologique de la situation, d'exécuter des actions correctives ou conservatoires nécessaires.

Le CEA est tenu d'intervenir dans les cas suivants :

- ➢ sur l'ensemble du territoire métropolitain et de ses eaux territoriales, à la demande du Commissaire de la République territorialement compétent (ou de leurs représentants). Le CEA intervient alors sous son autorité.

  Dès leur arrivée sur les lieux, les équipes CEA s'intègrent au dispositif de secours des pouvoirs publics, coordonné, sur les lieux de l'événement, par le responsable des secours
- ➢ lorsque les secours ne sont pas dirigés par les pouvoirs publics, à la demande :
  - d'un transporteur de matière radioactive ;
  - d'industriels, exploitants nucléaires ou non, dans le cadre de conventions d'assistance ou de protocoles signés avec le CEA ;
  - d'un tiers, victime ou témoin d'un événement à caractère radiologique réel ou présumé, en vertu du principe d'assistance immédiate à toute personne en danger.

  Dans un tel cas, le CEA informe immédiatement de son intervention la Préfecture du lieu de l'événement.

Nota : les missions d'assistance du CEA se bornent à la phase d'urgence terminée par la mise en sécurité stabilisée et durable de la zone. Une fois cette mise en sécurité réalisée, toute éventuelle prise en charge de substances radioactives, ou réhabilitation de la zone ne pourra être réalisée qu'après concertation et accord entre les entités CEA concernées, le responsable de la zone (Préfet ou industriel), et les éventuels organismes nationaux concernés (Agence Nationale pour la gestion des Déchets RAdioactifs (ANDRA), Office de Protection contre les Rayonnements Ionisants (OPRI), ...).

2.1. Organisation du cea pour assurer ses missions d'assistance

L'organisation du CEA en vue de l'intervention comporte :

- une structure d'alerte permanente ;
- une structure décisionnelle centrale ;
- des moyens d'intervention fixes ou mobiles répartis sur le territoire français.

1 - **structure d'alerte permanente**

La structure d'alerte nominale du CEA pour ses missions d'assistance, repose sur trois entités :

- la Direction Centrale de la Sécurité (avec l'astreinte cadre CEA hors heures ouvrables) ;
- le PC Intervention Nucléaire du CEA/Le Ripault ;
- le Centre de Liaison et de Transmission (CLT) de l'IPSN.

Ces trois entités peuvent être jointes à tout moment et se répercutent les alertes entre elles.

En outre, à toute heure, tous les établissements CEA peuvent être le point d'entrée d'une alerte ; ils la répercutent alors sur la structure d'alerte nominale.

2 - **structure décisionnelle centrale**

La responsabilité générale des missions d'assistance du CEA au sens de la présente note est confiée au Directeur Central de la Sécurité (DCS).

Le DCS, ou la personne qu'il aura désignée :

- fait assurer les liaisons entre le CEA et l'entité sollicitant l'assistance du CEA ;
- détermine, en accord avec l'entité sollicitant l'assistance du CEA et avec les Directeurs des Centres CEA concernés, les moyens du CEA devant intervenir ;
- fait assurer la mise en œuvre opérationnelle des moyens du groupe CEA ;
- se tient informé de la situation ;
- assure l'information des entités CEA concernées (selon l'événement : Administrateur Général, Direction de la Communication, Direction des Applications Militaires, Direction des Relations Internationales, ...) ;
- tient informé et prend l'avis des experts CEA ou extérieurs (IPSN, OPRI,...) ;
- tient informé, si nécessaire, les pouvoirs publics nationaux (Direction de la Sûreté des Installations, (DSIN), Direction Générale de la Santé (DGS), Direction de la Défense et de la Sécurité Civiles (DDSC)) de l'évolution de la situation ;
- désigne, au cas où plusieurs équipes CEA sont mises en œuvres, le responsable des agents CEA présents sur le terrain.
- décide de la mise en œuvre du Centre de Coordination en cas de Crise du CEA si l'ampleur de l'événement le nécessite.

Hors heures ouvrables, le cadre d'astreinte CEA assure ces missions pour le compte du DCS.

3 - Moyens d'intervention

Les moyens d'intervention que le CEA peut être amené à mettre à disposition sont des équipes d'intervention, un Conseiller Technique en Intervention Nucléaire (CTIN), des laboratoires de mesure fixes, des moyens d'intervention robotisés.

Ces moyens sont mis en œuvre :

- à la demande de DCS ;
- après accord des Directions des Etablissements CEA auxquels ils sont rattachés, et de l'autorité responsable de la mise en œuvre des secours ;
- après avis du chef des équipes CEA éventuellement déjà présentes sur le terrain.

Nota : lorsque l'urgence le justifie, et en vertu du principe d'assistance immédiate à toute personne en danger, un Directeur de centre qui serait sollicité directement pour une assistance peut être amené à mettre en œuvre ses moyens en prévenant DCS, mais sans attendre son aval.

a - Equipes des zones d'intervention de premier échelon

Les équipes des zones d'intervention de premier échelon (équipes ZIPE), placées dès leur arrivée sur les lieux de l'événement sous l'autorité du responsable des secours, peuvent être essentiellement amenées à établir un premier diagnostic, à proposer ou à prendre des mesures conservatoires.

Elles doivent notamment être capables :

- de se porter sur les lieux de l'intervention, aussitôt que possible après l'alerte ;
- d'effectuer des contrôles simples de radioactivité ;
- de dégager, en concertation avec les différents experts présents, une première évaluation des conséquences radiologiques de l'événement (vis à vis de la population, de l'environnement, et des équipes de secours) ;
- de déterminer, si besoin est, une zone d'exclusion et d'entreprendre son balisage ;
- de déterminer et de prendre les mesures correctives ou conservatoires immédiates pour mettre la zone en situation de sécurité stable et durable ;
- d'assurer leur propre radioprotection.

Ces équipes ZIPE ne sont autorisées à quitter leur centre CEA de rattachement qu'après accord explicite de leur Direction de Centre.

b - Equipes d'intervention de deuxième échelon

Les équipes d'intervention de deuxième échelon, disposant de moyens plus lourds et plus spécialisés que les équipes ZIPE, doivent être considérées comme des renforts ou des relèves des équipes ZIPE déjà engagées sur le terrain.

Selon les circonstances, leur mise en œuvre en un point quelconque de métropole peut nécessiter plus de douze heures.

Ces équipes ne sont autorisées à quitter leur centre CEA de rattachement qu'après accord explicite de leur Direction de Centre.

c - Conseiller Technique en Intervention Nucléaire

Le CEA peut mettre à disposition, aux côtés du responsable des secours, un Conseiller Technique en Intervention Nucléaire (CTIN), spécialiste en radioprotection et en intervention sur événement radiologique.

En accord avec le responsable des secours, le CTIN est chargé :

- de représenter le CEA, et d'assurer la liaison avec DCS ;
- de présenter au responsable des secours le point de vue du CEA concernant l'impact radiologique de l'événement, ainsi que les mesures et les moyens à mettre en œuvre ;
- de superviser les moyens CEA engagés, de veiller à leur intégration dans le dispositif général des secours ;
- de solliciter rapidement des renforts CEA appropriés ;
- d'interpréter et d'expliquer au responsable des secours les données techniques relatives aux événements radiologiques ;
- si nécessaire, de rappeler les spécificités de la gestion d'un événement à caractère radiologique au responsable des secours.

d - Moyens robotisés du GIE INTRA

Pour leurs besoins propres, le CEA, la COGEMA, et EdF disposent d'un parc d'engins robotisés (d'intérieur ou d'extérieur) pouvant intervenir dans des milieux contaminés ou irradiants.

Afin d'éviter des expositions aux intervenants, le CEA peut être amené à utiliser ces moyens. Leur délai de mise en œuvre peut aller jusqu'à 24 heures pour les moyens les plus lourds.

e - Moyens fixes des centres CEA

Pour effectuer des mesures radiologiques fines, le CEA peut mettre à disposition ses laboratoires de mesure pour analyser des échantillons.

4 - Rôle du PC Intervention Nucléaire

En plus de son rôle dans la structure d'alerte, le PC Intervention nucléaire (PC/IN) du CEA/Le Ripault a également pour mission :

- de gérer la disponibilité et la relève des équipes d'intervention ;
- de transmettre aux Centres les mises en alerte ou en alarme des moyens d'intervention ;
- d'assister les moyens CEA lors de leurs déplacements (logistique, itinéraires, personnes à contacter...) de façon à les diriger le plus efficacement possible vers la zone concernée et vers le responsable des opérations de secours ;
- de faciliter la communication des informations entre les différentes entités impliquées ;
- de centraliser l'ensemble des renseignements relatifs à l'intervention et d'établir des synthèses régulières pour DCS et les principales entités impliquées ;

3. Mission particuliere du cea pour le controle des produits radioactifs.

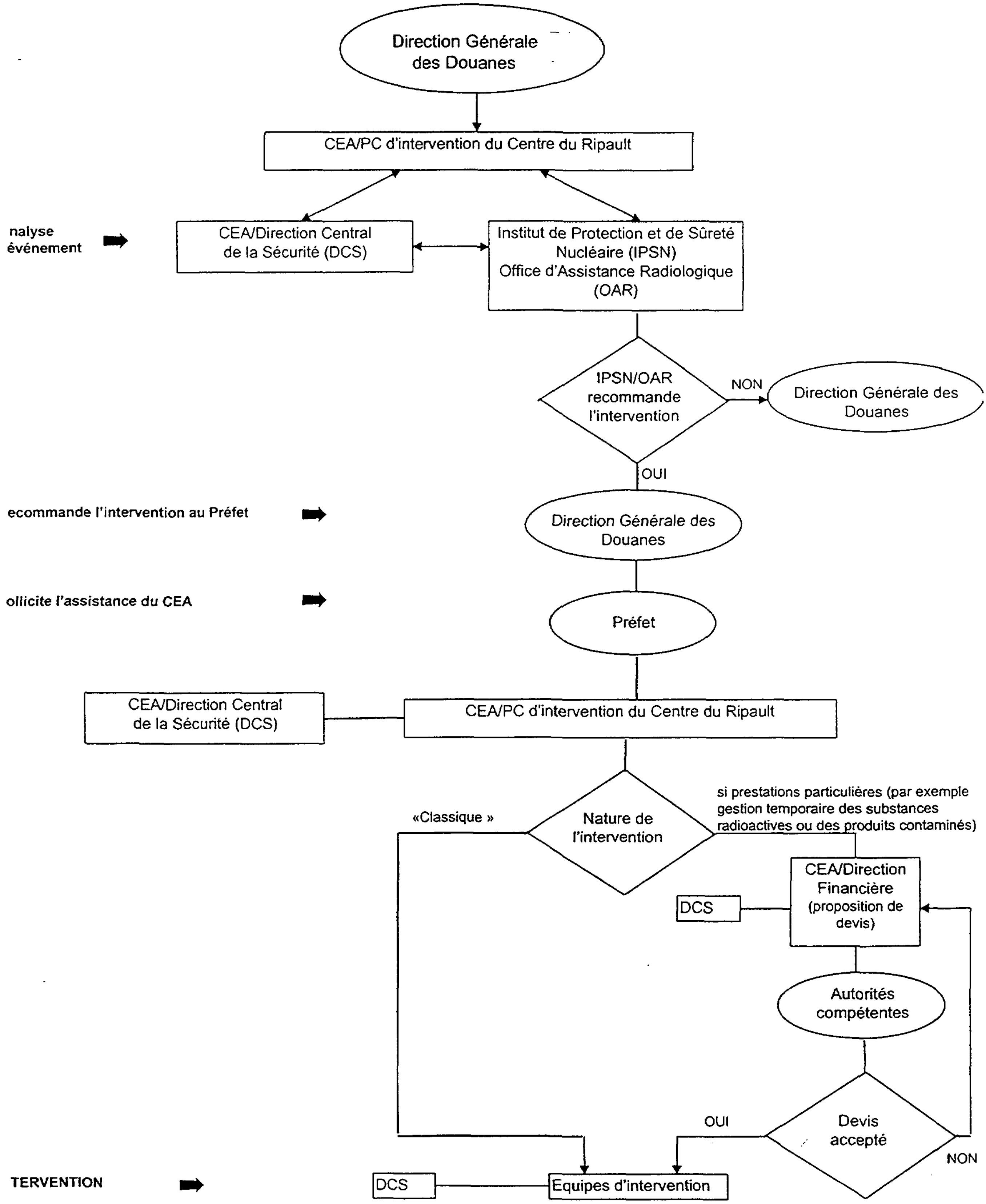
Conscients des risques liés à la circulation des matières radioactives et de leur aggravation liée à l'augmentation des trafics illicites, la douane et le CEA ont engagé une coopération dès 1994.

Il s'agissait de mettre en place une expérience de coopération dans un nombre limité de services douaniers pour renforcer leurs contrôles sur l'ensemble de ces produits. Une expérimentation de six mois a été menée au cours de laquelle le CEA a apporté l'assistance technique nécessaire aux contrôles qui demeurent de la seule responsabilité de la Douane. Il a mis à la disposition de cette administration des équipements de détection et de radioprotection. Il a aussi assuré la formation technique et pratique des agents des Douanes (encadrement et agents d'exécution).

C'est pour pérenniser cette collaboration que les Douanes et le CEA ont élaboré un protocole d'accord, dont le champ d'application couvre les champs suivants :

➢ soutien technique du CEA à la Douane, en particulier pour :

- l'acquisition et la mise au point de matériels de détection (radiamètres portables, destinés au contrôle rapproché, aux investigations et à la localisation précise d'une source de rayonnement, dosimètres individuels électroniques destinés à la protection du personnel en temps réel à l'égard des risques d'exposition qu'il pourrait encourir), Le dispositif mis en place au CEA correspond au schéma suivant :



- la détermination des conditions d'utilisation des matériels par les services douaniers.

➢ échanges d'informations pour accroître l'efficacité des contrôles douaniers,

➢ formation des agents des douanes au contrôle de la radioactivité : réglementation applicable aux transports, objectifs et bases-juridiques des contrôles techniques du maniement des matériels et leur doctrine d'emploi.

➢ mise en place d'un dispositif d'alerte et d'assistance en cas de détection par les services douaniers de substances radioactives ou de produits contaminés.

3.1. Demande d'assistance

La Direction Générale des Douanes peut demander l'assistance du CEA dans les cas suivant :

- doutes lors d'un contrôle,
- besoins de renseignements techniques,
- dès lors qu'un périmètre de sécurité est établi : lorsque leur dosimètre se met en alarme, les agents des douanes établissent un périmètre de sécurité, le débit dose à l'extérieur de ce périmètre restant inférieur à 2,5 μSv/h.

Les agents des Douanes contactent alors le PC intervention du centre CEA du Ripault.

3.2. Intervention du cea

On appelle intervention une opération impliquant un déplacement de personnes et de moyens techniques tels que des détecteurs.

Le CEA est averti de la situation par la Direction Générale des Douanes, mais l'intervention ne sera exécutée que sur demande exprimée par le Préfet.

L'intervention du CEA a pour objectifs d'effectuer un diagnostic radiologique de manière à prendre, si nécessaire, les mesures correctives ou conservations immédiates.

La destination des marchandises saisies à l'occasion de la constatation douanière est fixée par les autorités compétentes (le Préfet notamment).

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IMPORTANCE OF THE AWARENESS, TRAINING, EXCHANGE OF INFORMATION AND CO-OPERATION BETWEEN REGULATORY AUTHORITIES AND CUSTOMS, POLICE AND OTHER LAW ENFORCEMENT AGENCIES.

XA9848255

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Abstract

Fast developments in science and technology are a great accomplishment in this century These facilities have been utelized by criminals and deviants by indegnified way Industrial developed countries have their own means to improve and to modify technology and scientific facilities to cope up with any new existing problems, such as the problem of illegal traiding of nuclear materials Facilities for exchange of information among industrial countries also play an important role to prevent any dangrous phenomena may exist

In contrast most developing countries lack the means of uptodate follow up quick and continous scientific and technological developments. However they have qualified personnel to follow up quickly and to prevent drug and narcotics smuggling

Recently we have heard about a dangerous phenomena, the illegal trading of nuclear materials, which derive attention internationally The developed countries can cope easily with it However, in developing countries, their lack of up todate facilities can cause a greate damage to their nations Libyan Arab Jamahirya is always willing to co-operate internationally to prevent any new dangerous phenomena We think it is a time for conformation on international official agreement regarding this phenomena

Exchange of information between different countries through an international agency is important for prohibiting the illegal nuclear materials trading Also to help in creation of a temperoraly scientific committee to provide different countries of the world the available information in this area and to co-operate specially with police, custom and law enforcment agencies of each nation providing an international legislation for dealing with such phenomena is a priority Assistance for the arrangment of training through IAEA is of great importance

Without any doubt we can say today the world is shrinking due to fast technological development in the transport facilities, communıcations and exchange of information As much as these developments helped in great accomplishment that ıs

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witnessed by the humanbeing However such facilities have been malfunctionally utelized by criminals and deviants with undegnified ways and in excessive ideological purposes to satisfy material greedings

In addition to that the criminals and deviants are always capable to develope new processes for their own use which in turn casts a great burden to policemen, custommen and to low enforcement agencies whom they lack new international laws to overcome newly created phenomena

The industrial developed countries have their own means to improve and to modify technological and scientific facilities which easily allow them to follow up and to control any new circumstances They doing so by their ability to manufacture sophisticated equipments as well their capability to improve it from time to time according to their need to tackel newly existing problems In addition to their ability to perform continous qualified training to their personnel which lead to provide them with highly qualified staff in the area required So their qualified personnel have the capability to detect odd cases in shorter period of time

Although in developing countries good qualified personnel existed to prevent the smuggling of the public used materials , such as electronics, food, medicine and others . as well as their intense concentration to prevent drug and narcotics smuggling These highly qualified personnel the policemen and custommen , have been created by good training and by their own hard work and by the help of scientific staff behind them who have the capability to detect and to analyse the different materials by utelizing scientific equipments available to them which was well selected from world market Burt still the developing countries lack the ability to produce their own scientific equipments to date.

However, we can not rule out the effect of co-operation between different countries for prohibiting drug and narcotics smuggling The international co-operation plays an important role in exchange of experiences, information and qualified technicians in this area In the mean time we can observe some mishapes from time to time in different countries regardles to their status This results from the modifications of the methods of smuggling by the criminals and from the colaboration or by the help of indelicate people to facilitate their dirty work

Recently many countries are somewhat fearful of the existence of new phenomena, the illegal trade of nuclear materials.

The manufacturing countries of nuclear materials have the capability to deal with this phenomena due to their scientific facilities and of their highly qualified personnel that can overcome the smuggling of such type of materials, quick detection of different types of such products within a short period of time Also they have the capability for safety precautions, controlling and overcoming any accidents which may occur during the process of manufuture, transport and storage of the nuclear materials They also have an axcess to obtain information about the persons or the secret criminal organizations from the continous co-operation in the exchange of information among the industrial countries

The situation is quite different for the developing countries because of their lack of means to cope up with quick scientific progress and many of these countries do not have highly qualified experts and related scientific equipments to deal with or to prevent the smuggling of such type of materials on spot. Also their limited facilities for transfering the suspected materials to their own research centers , if it exists, this may cause harm to personnel due to their ignorance about these dangerous materials The transportation of such materials could cause pollution to the area results from the lack of facilities of a dequate equipment that can be used during transportation of such materials to the research center for analysis

The lack of information and co-operation among the countries increase the scope of the problem

Information about secret criminal organizations that may deal with the trade of nucluear materials is quite important to overcome this new phenomena

It is unfortunately due to the abscence of low organization agents between the countries for preventing this dangerous phenomena which create a big gab for dealing with the criminal act in this area can increase the nature of the problem

We have to think quickly and seriously to build up scientific means to close up the gaps between different ideas to deal up with the phenomena

Libayn Arab Jamahirya always have an intention as well as ready to fight dangerous unhuman phenomena and always willing to co-operation internationally in dealing with limitation and preventing any dangerous phenomena that may effect international safety that may result from worldwide smuggling and illegal trading of such type of materials Libayn Arab Jamahirya have also great believe on fighting the terrorestic acts and smuggling Here in Jamahirya, they are doing their best on going improvement of the qualification of the scientific staff and the technicians as well as to police and to customs personnel to cope up with any new circumstances

Libyan Arab Jamahirya have highly qualified personnel for preventing the smuggling of different materials especially in the area of drug and narcotics smuggling Their personnel quite aletr and can detect and prevent the smuggling due to their highly experiences in this area They can detect these materials with a shorter period of time

We can not role out the effect of the official agrement among Arabic brothers for exchange of informations about smuggling As well the international official agreements for prohibiting drugs and narcotics smuggling

An international organization for prohibiting drugs and narcotics smuggling is already established The organization is doing its best to provide exchange of information and communication internationally as well as organizing from time to time international conference and also regional conferences in this field

Unfair sunction by security council on Jamahirya which is quite unjustified cause a great damage to the nation in health education and social programs We are in need to train a qualified personnel outside the country as soon as we can be able to obtain quite modern equipments by co-operation with industrial countries and we are doing our best to overcome the unfair sunction but we still need international support which in fact increases day by day

International atomic energy agency help for training and for obtaining facilities to prevent any illegal nuclear materials trade which may occur is required

Due to our awareness and outstanding thinking about this dangerous phenomena we will do our best to take all the precautions to prohibit it according to our facilities

Now it is time to think seriously till we reach international official agreement on this phenomena and the formation of an international organization for prohibiting smuggling, nuclear matrials and its illegal trading typical in equivalence to drug and narcotics prohibiting organzation where we can suggest the folowing

1- Confirmation on international offecial agreement regarding this phenomena
2- assistance for the arrangement of training and exchange of informations between different countries especially with customs , police and low enforcement agents
3- Providing the posibility to facilitate obtain up todate scientific equipments and tools
4- Proposing an international legislation for punishment of the criminals who create this phenomena

where this proposal may be submitted to all countries via the international atomic energy agency.

In the mean time we can start by creating a temporarly scientific committee to provide to different countries of the world the available information in this area the methods aleady utelized for contorling such phenomena. The scientific commette should engage in organizing international conferences from time to time to give more insight about prohibiting the illegal nuclear materials trading and smuggling

Although we believe with great need to co-operate internationally to fight this phenomena We still think about the countries which produce such type of materials and should have moral commitment and responsibility for any hazards which occur during manufacturing transportation, storage or on waste disposal of the nuclear materials tha may cause ecological damage to other countries or harm persons So it will be justified to implement on them to pay all the costs for cleaning up the effected area and to pay personal compensation as well as to provide the facilities and qualified personnel to help the country that is exposed to such damage