Control and Management of Radioactive Material Inadvertently Incorporated into Scrap Metal

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Tarragona, Spain
23–27 February 2009

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International Atomic Energy Agency

CONTROL AND MANAGEMENT OF
RADIOACTIVE MATERIAL
INADVERTENTLY INCORPORATED
INTO SCRAP METAL

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PROCEEDINGS SERIES

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FOREWORD

Radioactive material may become inadvertently associated with scrap metal and, when melted, can cause ill health effects as well as economic and public acceptance problems for the metal industry. This issue has come to the forefront in recent years and concerns have been voiced by the metal recycling and production industries. Action to prevent the occurrence of such events has been taken in many countries exerting greater control over radioactive sources. Monitoring metal scrap at borders and at entrances and exits to scrapyards and melting plants and by preparing response plans will help prepare countries for such events if they do occur. It is recognized that this problem is a global one because of the transboundary nature of the scrap metal trade and, therefore, it is particularly suitable for discussion in an international forum.

The aim of the International Conference on Control and Management of Radioactive Material Inadvertently Introduced into Scrap Metal was to share experiences and, if possible, to contribute towards the resolution of the problems caused by the inadvertent presence of radioactive material in scrap metal. It was held from 23 to 27 February 2009 in Tarragona, Spain and was organized by the Spanish Nuclear Safety Council in cooperation with the IAEA.

The conference consisted of five plenary, four panel and a poster session. It was attended by more than 200 participants. Forty oral and 38 poster contributions from more than 60 countries and international organizations were presented.

These proceedings include the opening speech, papers presented orally, summaries of the five plenary sessions and the conclusions of the conference. The PowerPoint presentations are on the attached CD-ROM.

The IAEA gratefully acknowledges the support and generous hospitality of the Government of Spain.

EDITORIAL NOTE

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CONFERENCE SUMMARY

Radioactive substances can become associated with scrap metal in various ways and if not discovered they can be incorporated into steel and non-ferrous metals through the melting process. This can cause health hazards as well as environmental concerns and there can be serious commercial implications. Numerous incidents have occurred in recent years involving the discovery of radioactive substances in scrap metal and, in some cases, in metal from the melting process. These incidents have proved to be very costly in relation to the recovery and cleanup operations required but also in terms of the potential loss of confidence of the industry in scrap metal as a resource. This has led the scrap metal industry to seek ways of managing the problem.

In most countries, shipments of scrap metal are monitored but at different points in the distribution chain and to different extents and efficiencies. As yet, only limited efforts towards unifying and harmonizing monitoring strategies and methods in the context of scrap metal have been made at the international level.

The Conference was organized into five sessions: the global perspective, national policies and strategies, compliance with radiological criteria, management of incidents with contaminated scrap metal, and improving confidence and protecting the interests of stakeholders.

The aim of the first session was to present the views and perspectives of the different organizations concerned with radioactive material in scrap metal, scrap metal recycling, steel making, radiation source security and safety and international trade and economics.

The second session covered some of the national policies and strategies being used to address the control of radioactive material that has been inadvertently incorporated into scrap metal were presented. In addition to the oral presentations, contributions describing the situation in many countries of the world in the form of posters were displayed. The many posters reporting national measures being used to control radioactive material in metal scrap at the conference served to indicate the global extent of the problem.

In the third session, international criteria relevant to the release of metals from regulatory control were presented. Methods for ensuring compliance with the criteria and for detecting radioactive materials in scrap metal were also discussed.

A number of incidents and experiences with scrap metal containing radioactive material were described in the fourth session. These presentations illustrated the wide range of monitoring being used in different countries. Since the scrap metal industry is truly global, with loads moving between most countries, these differences in the level and extent of monitoring help explain the continuing problems with radioactive material in scrap metal.

The final session of the conferencefocused on public perception. The public, in most countries, is concerned about the hazards of ionising radiation and when there is a risk that radioactive material can be present, for example, in metal products. The session contained presentations on the views of the recycling industry, of a national regulator, of an expert in risk perception and communication and of a journalist.

OPENING SESSION

OPENING ADDRESS

E. Amaral
International Atomic Energy Agency
Vienna, Austria

Welcome and introduction

Good morning ladies and gentlemen.

It gives me great pleasure to represent the IAEA Director General in the opening of the International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal.

This conference is a unique and important opportunity for regulators and representatives from industry to exchange knowledge and share experience on the many aspects of radiation safety involved in the recycling of scrap metal.

Let me begin with an acknowledgement and an expression of my appreciation for the Spanish nuclear safety commission for organizing this important event that brings together such a diverse group of international experts. The country of Spain is an active contributor to international efforts in nuclear and radiation safety and we are thankful to them for this.

Please allow me here to place the radiation safety mission of the IAEA in a broad context with a brief description of our current and future challenges:

Safety and security

Safety and security are both essential to the protection of people and the environment, and as noted in the IAEA Safety Fundamentals publication, SF-1, Safety Measures and Security Measures Must be Designed and Implemented in an Integrated Manner. Our challenge is how to achieve this as early and as effectively as possible.

New entrants

The introduction of nuclear technologies in countries that heretofore were without nuclear programmes is an issue of concern for the global nuclear community. Therefore, it is imperative that new entrant nuclear programmes are launched with the goals of protecting people and the environment.

The global nuclear community needs to do its part to ensure that these new entrant programmes benefit from the lessons learned from the many decades of experience in the implementation and regulation of nuclear technologies.

Medical exposures

The IAEA has a leading role in establishing safety standards and informing and training health professionals worldwide through efforts under the International Action Plan on the Radiological Protection of Patients. However, as new medical imaging and complex radiation therapy techniques are being introduced, accidental exposures of patients continue to be reported, and there are new reports of unnecessary and unintended exposures. As a result, Member States have encouraged the enhanced application of the safety standards to reduce the frequency of over- or underexposures in nuclear medicine. It is important to meet this evolving challenge with the continuing identification and application of lessons learned and the development of standards of safety in this area of rapidly growing technological complexity.

Uranium mining

After many years in economic stagnation, the uranium industry is experiencing a resurgence of activity. The upsurge of uranium fuel cycle activities has significant implications for radiation safety in general, and for the radiation protection profession. At every stage of the uranium production cycle, from exploration through mining and processing to fuel fabrication, there are requirements for appropriate radiation protection procedures and regulation to protect people and the environment. The long period of reduced activity in uranium mining has led to a shortage of trained and experienced radiation protection professionals associated with the mining industry that will be difficult to overcome. The IAEA is working with radiation protection authorities and uranium mining industry representatives worldwide to address the current shortage of qualified personnel.

The inadvertent introduction of radioactive material into scrap metal destined for recycling, which is the focus of this conference, is becoming an increasingly important challenge. Incidents, associated with the presence of orphan sources and other radioactive material in scrap metal, have occurred since industrial activities have used and produced radioactive material. The consequences of accidents such as those in Goiania and Samut Prakarn and recent security concerns regarding some types of radioactive material, as well as the international aspects of the scrap metal trade have made these incidents unacceptable for society. However, these incidents occur, and in the last three years the IAEA has become aware of around 500 events involving uncontrolled ionizing radiation sources, about 150 of which were related to sources found in scrap metal, or contaminated goods or materials.

After half a century of the nuclear age, there are an increasing number of nuclear facilities that have reached or exceeded their operational lives. In today's society, with an enhanced emphasis on environmental considerations, greater attention is being paid to the effective decommissioning and remediation of nuclear facilities and sites, and the recycling of as much of the metals used at these facilities as possible. Any incident associated with the presence of radioactivity in scrap metal could be harmful to people and the environment. Furthermore, the trust that the public places in the government and the nuclear industry could be damaged.This in turn could result in an inappropriately conservative application of clearance procedures, and the treatment of more material that does not present a hazard as radioactive waste.

To combat these issues, some countries and regions have initiated or increased their efforts to prevent radioactive sources from becoming orphan sources. Many countries are also taking steps to better manage disused sources and radioactive residues, and to establish sustainable bridges between the decommissioning industry and the steel industry. But, it should be emphasized, that this is clearly a global problem that requires a harmonized approach worldwide.

The programme of the Conference has been structured to present the challenges to the global scrap metal industry and those of the nuclear decommissioning industry. This Conference will address global and regional frameworks that deal with the control of radioactive residues in these industries and the identification of gaps in this control.

The best practices of countries that have adopted policies and developed strategies to detect and avoid the inadvertent introduction of radioactive residues into scrap metal will be presented. We will see that in these countries, the number as well as the social and economic costs of incidents have decreased as cooperation and confidence has been developed among the stakeholders; including nuclear and non-nuclear industries, the regulatory bodies, and the public.

Lessons learned from recent accidents and incidents will also be discussed. As demonstrated by statistics that are maintained by the IAEA, these incidents continue to happen. We should be thankful that recent accidents have not approached the consequences of the Goiania and Samut Prakarn accidents, but we should also remember that the potential for such accidents remains.

The recycling and reuse of materials is a fundamental principle for a sustainable environment. A functioning radiation safety infrastructure should allow for the recycling of materials that have been used in practices that contain trace amounts of radioactivity at levels that can be removed from regulatory control. However, the public's fear of radioactivity and risk perception may influence regional or national authorities in the way they establish a regulatory framework to clear radioactive material from regulatory control. A session of the conference on improving confidence and protecting the interest of stakeholders will explore the various dimensions of this issue.

The IAEA will give careful consideration to the outcomes and conclusions of the conference and will adjust the focus of its work programmes accordingly. Hopefully, we will all take away from the conference ideas to ensure that we are able to provide the positive answer that is needed in response to this societal concern.

In closing, I note that I see the straightforward reason that our Spanish hosts have chosen Tarragona as the setting for this Conference. We are close to one of the operating Spanish nuclear sites, and a site where a nuclear power plant was decommissioned and a substantial stock of metal resulting from this decommissioning was cleared from regulatory control and recycled. But, I am also impressed that in this city, for the last four thousand years, an important harbour has been open to the Mediterranean world. During the time of its operation, globalization has swept the world and its effects on many subjects can be felt in this city. Today is for our subject.

The organization of this first conference on the subject is therefore very timely and important. We are extremely thankful to the Spanish Nuclear Safety Commission for this initiative and to have invited the IAEA to co-organize this event.

I hope that we will all be able to take away from the conference ideas on what we can do to provide positive answers to all these questions. In conclusion, I would like to wish the conference every success look forward to discussing the outcome and conclusions of the conference with you on Friday.

Thank you

GLOBAL PERSPECTIVE

(Session 1)

Chairpersons

A. GARCÍA FRANCO
Spain

J.I. BARTOLOMÉ
Spain

Rapporteur

J. LORENTE
Spain

M. HANNAN
IAEA

SUMMARY OF SESSION 1

GLOBAL PERSPECTIVE

For the metal industry, the potential presence of radioactive material in scrap raises concerns regarding the reliability of scrap as a key source material for metal manufacturing. Inadvertent radioactivity found in scrap is mainly due to naturally occurring radioactive material (NORM) and orphan sources. The consequences of melting incidents involving radioactive material are mainly economic, with costs running into millions of euros. However, another concern could be the loss of confidence in the quality of the metal product. At the present time, scrap metal is an important source material for the metal production industry contributing a large fraction (about 50% for steel) of the final product. It is noted, in this context, that the amount of steel scrap resulting from the decommissioning of a nuclear reactor is a very small fraction of that being used by the steel industry annually.

Radioactive sources offer a wide range of beneficial applications in medicine, industry and research.Scrap reuse through melting offers substantial savings in use of raw materials and energy for processing and so the recycling of scrap will continue.

International and regional organizations responsible for the protection of workers and the public against the effects of ionizing radiations have sponsored instruments such as the international Code of Conduct on the Safety and Security of Sealed Radioactive Sources and the European Directive on High Activity Sealed Sources (HASS Directive). These instruments provide proper administrative means to control and secure sealed radioactive sources in each country. However, these instruments do not address the issue of inadvertent radioactive materials in scrap metal. To date, the only international guidance in this context comes from the UN Economic Commission for Europe which, in 2006, issued a set of recommendations on monitoring and response procedures for radioactive scrap metal.

Increased international attention has been given to the control of radioactive sources in recent years, for example, through the international Code of Conduct. However, there does not appear to have been any significant reduction in the number of reported incidents involving radioactive material in scrap. This could be attributable to the fact that many sources which appear as orphan sources are quite old and may already be outside the ‘control system’. The expansion and improvement in detection methods used at borders, scrapyards and metal works may also play a role.

Finding the organization/person responsible for the radioactive material appearing in scrap metal is often difficult and therefore hard to recover the often substantial costs associated with cleanup and loss of production. In this case the polluter usually does not pay.

The nuclear industry considers the recycling and reuse of metal from the decommissioning of nuclear facilities an important strategy. The alternative — disposal — is wasteful, and becoming increasingly costly. Clearance is used to determine which parts of decommissioned materials can be released from regulatory control. At present, cleared materials from the nuclear industry are used in applications which are in some way controlled, such as reuse within the nuclear industry or use for applications which have very low probability of coming into contact with the public. The unrestricted release and use of cleared materials is not widely accepted. As more nuclear facilities are decommissioned, this issue may increase in significance in the future.. National policies vary on this matter with clearance being accepted in some countries but rejected in others. The metal industries are, for the most part, reluctant to accept cleared material, partly to avoid any possible risks of melt contamination but also in response to the concerns of the public.

The following topics were discussed in the Panel held after this session:

The need for improved controls over scrap metal loads moving between countries was highlighted. At present, there is no requirement for certification of radiation monitoring of loads. However, due to the limited resources of some scrap companies, certification was considered by some to be unfeasible. It was also pointed out that there is no agreement on what procedures to adopt when a load has triggered radiation detector alarms at the borders.

The discovery of radioactive material in scrap can bring difficulties with the authorities, a loss of production and a waste of time. These negative implicatons can cause such incidents to be hidden from the authorities. However, if finding radioactive material were to be seen as a positive occurrence, one that merited awards to persons, then this could lead to greater openness in reporting.

There are communication problems between the metal industries and the nuclear industry. The concerned groups, such as the trade unions, do not understand each other and the terminology used. An international forum to promote dialogue could help the groups understand each other and might possibly lead to solutions to the common problems that they face.

CHALLENGES IN THE MANAGEMENT OF POTENTIALLY CONTAMINATED SCRAP METAL

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Abstract

This paper describes the background and current status of the management of potentially contaminated metals and materials at the US Department of Energy (DOE) sites across the USA. The current DOE policy prohibiting the release of metal scrap for recycling from radiation areas is explained. Finally, a potential path forward to competently assess, characterize and clear material from radiological control is proposed that uses a combination of administrative processes and empirical techniques that are valid irrespective of the standard used for clearance.

1. INTRODUCTION

The US Department of Energy (DOE) operates and manages a vast complex of nuclear production and manufacturing facilities as well as national laboratories throughout the USA. Within the DOE, the Offices of Science, Environmental Management, Nuclear Energy and the National Nuclear Security Administration (NNSA) routinely handle and process radioactive materials as part of their respective organizational missions. With an inventory of unneeded facilities and obsolete equipment dating back to 1945, each of these organizations faces significant challenges in characterizing, decontaminating, decommissioning and disposing of materials generated as a consequence of past operations.

Although these materials are associated with operations involving radioactive materials, a large portion is not radioactively contaminated. Through properly planned and configured operations, the potential for causing additional contamination of metals and/or materials is significantly reduced. Similarly, efforts to raze obsolete structures and dispose of unneeded or unserviceable equipment can be performed in a manner that maximizes the generation of uncontaminated metals and materials.

Finally, developing and maintaining public confidence in radiological characterization and material clearance programmes is vital — regardless of what standard or type of protocol is mandated for use. Any programme or process used in radioactive material control must be transparent, auditable, and easily explained to interested members of the public.

2. BACKGROUND

In 1998, the DOE began an ambitious project directed at the decontamination and decommissioning of the Oak Ridge Gaseous Diffusion Plant[1]. This project involved over 10 million square feet of floor space containing 1.7 million tons of carbon steel, nickel, copper and aluminum used in the process equipment. Cost estimates for completion of this work exceeded $1 billion (1993 estimates). However, it was estimated that by decontaminating the metals followed by their sale for recycling into general commerce, the costs could be reduced to $235 million. Because of its effect on the total project cost, recycling became a vital component of financing the project.

Public concern soon developed regarding the adequacy of the existing standards for the release of materials from radiological control and the ability of the DOE to adequately oversee such a large project. This concern resulted in a re-examination of the large scale release of metals into commerce from decontamination and decommissioning projects underway or planned at DOE facilities. This effort revealed several areas for improvement in the processes for release and the associated protocols and in the record keeping related to individual release events.

In a memorandum dated July 13, 2000, the Secretary of Energy directed the DOE programmes to improve:

— The DOE's release criteria and monitoring practices;
— Efforts to expand and promote reuse and recycling within the DOE complex of facilities;
— The management of information about material inventories and releases.

Through the memorandum, the Secretary also temporarily suspended the release of scrap metal for recycling, if the scrap metal was managed or generated in a radiological area as defined by Title 10 Code of Federal Regulations Part 835 (10 CFR 835), 'Occupational Radiation Protection' after July 13, 2000. This suspension was to remain in effect until appropriate improvements could be made

[1] The Oak Ridge Gaseous Diffusion Plant, also known as 'K-25' was the first uranium enrichment plant using gaseous diffusion technology. The plant was operational 1945–1984.

in the DOE directives (specifically the DOE Order 5400.5) and in the associated guidance. The revised DOE directives and guidance were to establish a process to ensure that scrap metal recycled into commerce (unrestricted recycle) contained no detectable residual radioactive material resulting from DOE operations. Programme Secretarial Officers were to be responsible for certifying that these requirements were met for individual sites under their management control.

The required directive revisions and guidance were developed and proposed but in a subsequent memorandum dated January 19, 2001, the Secretary opted not to issue the revision. Instead, the Secretary extended the suspension in order to more fully develop the revisions and guidance and to engage the public in the process of review and comment on DOE 'property and material clearance criteria and processes' through the development of an Environmental Impact Statement (EIS). It was envisioned that this process would provide a structured approach to examining the environmental consequences of using various routes for the disposition of the materials and scrap metal accumulating at DOE sites. As part of that decision, the Secretary also recognized the ongoing efforts of the US Nuclear Regulatory Commission (NRC) in in establishing national standards for the clearance of material from regulatory control. Additionally, the Secretary provided clarification of the improvements required by the July 13, 2000 memorandum and directed that DOE field operations:

— Clearly define areas and activities that can potentially contaminate property;
— Clearly define release criteria, including measurement and survey protocols for property released from areas or activities that have potential to contaminate;
— Ensure that released property meets the DOE requirements;
— Better inform and involve the public and improve DOE reporting on releases.

These improvements would be incorporated into existing release programmes at each site as a prerequisite to the resumption of clearance of scrap metal managed or generated in radiological areas on or after July 13, 2000. The DOE incorporated the improvements in its guidance for DOE Order 5400.5 implementation and in the guidance for preparation of the Annual Site Environmental Reports required under DOE M 231.1-1A, Environment, Safety and Health Reporting Manual. However, although a Notice of Intent to prepare an EIS was issued on July 12, 2001, and public scoping meetings were held, the draft EIS was never issued. Further, although the USNRC staff recommended a proposed standard in 2005, the Commission opted against proceeding and directed the staff to continue using the case-by-case process

3. CURRENT STATUS OF THE DOE RECYCLE POLICY

Currently, the temporary suspension on the release of scrap metal from radioactive areas for the purposes of recycling remains in place. Although guidance has been issued addressing ‘improvements’ to the control and release process [1, 2], little progress has been made in resolving the suspension. Sites across the DOE complex of facilities have adopted differing approaches to implementing and sustaining the policy since July 2000. This has resulted in varying approaches to implementing the policy, many of which are extremely conservative (e.g. withholding and/or disposing of scrap metal as waste). In this respect, due to the high costs of storage at some sites and/or disposal fees, the suspension has become costly. Furthermore, most of the metal is not low level radioactive waste (LLW), therefore it is not regulated by the Atomic Energy Act and can only be disposed of as sanitary waste or construction debris. An apparent contradiction is that local environmental regulations may require waste minimization through recycling. This has resulted in incidents where scrap metal disposed of in ‘good faith’ at sanitary landfills has been recovered and sold by the landfill operator. This situation is expected to occur more frequently as sites begin to dispose of the increasing stockpiles of scrap metal as storage capacity becomes scarce and areas become more expensive to obtain and maintain.

Ad hoc management approaches adopted by individual sites to cope with the Secretary of State’s suspension have proved ineffective, overly cumbersome, and costly in the long term. The DOE’s National Nuclear Security Administration has recognized the need for clear guidance on policy compliance as well as on consistent processes and procedures to support the clearance of materials at all of its sites. Activities are presently underway to assess the radiological clearance and radiation protection programmes at all NNSA managed sites for effectiveness. Through the application of consistent approaches, as well as competent oversight and control, NNSA hopes to regain the confidence of DOE management and the public and to resume the clearance of metals for recycling from radiation areas.

4. ADDRESSING THE CHALLENGE — IMPROVING SYSTEMS, PROCEDURES AND PUBLIC INVOLVEMENT

Overall, the primary challenge in managing potentially contaminated metals within the DOE complex of facilities is to establish and maintain the confidence of the internal and external (e.g. the general public) stakeholders. Stakeholders must be assured that management of radioactive materials and clearance of materials from radiological control is sound. Such confidence not only depends on the belief in the technical competence, but also on trust and on the continuous demonstration of the efficacy of control and clearance programmes. To achieve this goal, the Secretary of Energy has identified four key areas in material clearance and property management programmes for improvement:

— **Clearly define areas and activities that can potentially contaminate property.** The use of process knowledge to grade the approach to clearance programmes must be formalized in site procedures. Furthermore, operations must be planned and configured to minimize the generation and management of materials that are suspect for radioactive contamination. Ensuring regulatory compliance using 'conservative' approaches based on administrative convenience must be curtailed. Such areas should only be established based on empirically derived data from competent and quality controlled sources.
— **Clearly define release criteria, including measurement and survey protocols for property released from areas or activities that have potential to contaminate.** For property (other than scrap metal) that cannot be cleared using a process knowledge based approach, clearance and release documentation must demonstrate compliance with DOE Order 5400.5, Radiation Protection of the Public and Environment. Although the Order specifies limits for residual radioactive material that are consistent with the US Nuclear Regulatory Commission (NRC) and International Atomic Energy Agency (IAEA) standards, it requires that any residual radioactive contamination present should be 'as low as reasonably achievable'. Decontamination processes must be oriented to achieving this level of control. Although bulk (e.g. portal) monitoring is generally ineffective in detecting alpha, beta or low level gamma radiation, such devices should be incorporated into the clearance process to support a common baseline of characterization data used by the steel and metal recycling industries.
— **Ensure that released property meets the DOE requirements**. Independent verification of the effectiveness of contractor clearance programmes should be performed. To avoid actual or perceived conflict of interest, the Secretary directed that independent verification may be done by the DOE or by DOE support contractors. If contractor resources were to be used, "they must be independent of the operating contractor managing the property or responsible for the release survey or decontamination of the property".
— **Better inform and involve the public and improve DOE reporting on releases.** Site release policies and protocols should be coordinated with the

public, and public input must be considered in the DOE's development and approval of site release programmes. Documentation on releases must be made available to the public and to those entities receiving the released materials. In practice, this improvement can be easily integrated into routine public involvement and environmental reporting initiatives at individual sites.

Taken separately, each of the aforementioned improvement initiatives are simple in concept and easily implemented. However, to be maximally effective, they must be woven into a systematic approach to materials management and control. Figure 1 presents a seven step process for clearing materials from radiological control that embodies each of the aforementioned process improvements. Each step is referred to as a 'gate' to denote that material must pass affirmatively through that step to be candidate for clearance and ultimate release from regulatory control. Failure to pass any gate results in rejection of the material lot and either disposal as waste or return of the lot for additional processing followed by reassessment starting at Gate 1.

5. APPLICATION OF THE 7-GATE APPROACH AND ECONOMIC VIABILITY OF MATERIAL CLEARANCE

The 7-Gate Approach effectively integrates radiological characterization data derived from direct measurement with administrative review, statistically based verification and deliberate DOE involvement and oversight. Taken together, exercise of this system results in 150% to 460% survey frequency (Fig. 1) (depending on the origin and type of material presented for evaluation) of material lots evaluated. Further, through the application of automated processes, consistent documentation packages for each lot cleared can be automatically generated and archived. Communication with internal and external stakeholders is simplified and confidence in clearance programmes enhanced through a readily available audit trail for the process. Documentation packages are created for each lot of material released and the packages are archived for future use if needed.

A necessary concern with this approach is the cost of implementation of a seemingly large amount of rigour and management. However, closer inspection of the elements of the 7-Gate process reveal that the first four steps are already performed in any technically competent material clearance programme. The challenge is to systematize the application of these processes and to apply the discipline to integrate their implementation. Operations personnel must also recognize the interrelationship between the gates or steps. Cost for the first four steps should therefore be minimal, requiring a one time enhancement of management processes.

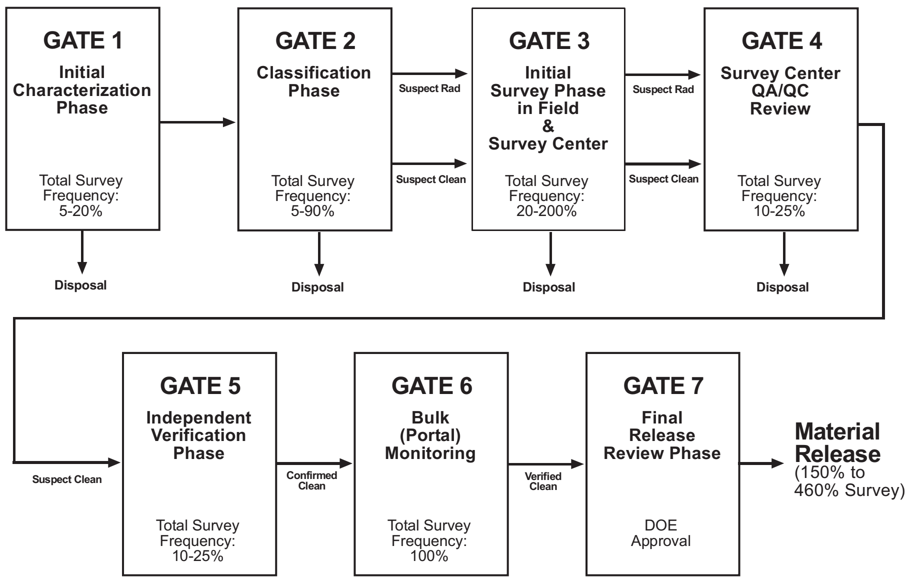

FIG. 1. Impacted scrap metal release protocol process flow.

Implementation of Gate 5 requires the development of a statistical approach to support independent verification of the conclusion of the collected outcomes of Gates 1–4. American National Standards Institute (ANSI) Z1.4-2003, 'Sampling Procedure and Tables for Inspection by Attributes', or a similar standard, can be used to determine sampling frequency and anomaly management procedures. This could achieve the desired confidence of the efficacy of the process in eliminating the potential for inadvertent release of radioactive materials. To eliminate any conflict of interest, it is suggested that this function be performed by an entity not contractually connected to the firm charged with primary survey and characterization responsibilities. The cost of implementing Gate 5 requirements can vary considerably depending on whether it is implemented on a lot or a programme basis. The selection of one of these implementation options will depend on the magnitude of the clearance effort to be undertaken. In the case of a major decontamination and decommissioning project, a lot basis may be the most appropriate to ensure adequate process control and to acquire and maintain public confidence. In a facility with ongoing operations, a verification effort may be more appropriate at a programme level, with periodic inspection exercises conducted randomly over the course of time.

Gate 6 is the bulk or portal monitoring of material that has been cleared from independent verification and all prior Gates and is ready for final release. Bulk monitoring also provides a credible means of measuring the cumulative effect of small amounts of radioactive material that may be present in a large number of individual items offered for recycle. Further, bulk monitoring is important because it is the technology used by commercial steel and scrap metal processors to ensure that radioactive sources are not introduced into the metal recycle stream. This final data collection step provides an assurance to the steel and metal recycling industries that materials released from DOE sites will not activate similar equipment present as commercial facilities. The cost of Gate 6 is equivalent to the cost of acquisition and maintenance of bulk or portal monitoring capabilities in the private sector.

The cost of Gate 7 is associated with the allocation of technical resources by the DOE to evaluate the results of the system and compliance with the application to release the metal or material from radiological control. This is usually done by a government official, and so it does not usually result in an additional marginal cost to the clearance process or project.

Application of the 7-Gate approach brings technical rigour, traceability, integrity, and confidence to materials clearance programmes. Because well designed programmes already include over 80% of the effort necessary to clear material from radiological control, little additional cost is associated with this approach. While independent verification represents additional operational costs, these can be minimized and managed effectively through clear articulation of programme objectives and goals and by standardization of procedures. These costs are more than offset by the integrity and credibility independent verification brings to the clearance process.

6. CONCLUSIONS

There are four basic challenges to managing metals and materials that are candidates for clearance and recycle from nuclear facilities. They are:

— Configuring work practices

Work practices must be planned and configured to reduce and/or eliminate the potential for contamination. In many cases, work practices are developed solely in support of the primary operational mission of the facility. Procedures that are convenient and efficient in this respect may not be optimal for minimizing the potential of contaminated materials. Work practices should be developed and/or revised to limit potential contamination of materials.

— Proper designation of radiation control areas

Similarly, at many facilities, permitted radiological operation areas are unnecessarily large. Justified as a ‘conservative’ approach to ensure radioactive materials are confined to demarcated radiation areas, this practice encourages poor contamination control and management of radioactive materials. Further, workers may be desensitized to the hazards of radioactive material if the major portion of the controlled area is overly demarcated.

— Technical rigour in material characterization and radiological survey

To be effective, administrative and technical aspects of material characterization must be integrated into a unified product. Process knowledge regarding the prior use and inventory history of the material must be used to determine the type and frequency of sampling and/or radiological survey. Acquisition of process knowledge should be formalized and responsibility assigned for its veracity. The 7-Gate process described in Fig. 1 integrates process knowledge into the clearance process. Process knowledge assertions are verified at each gate — continually increasing confidence that the material cleared meets applicable standards for release. Depending on the origin of the material, a survey frequency of up to 460% is delivered by the 7-Gate process.

— Public acceptance

Public confidence in the methods and efficacy of programmes, processes and procedures in controlling radioactive contamination is critical to the management of materials. The public must be assured that the appropriate amount of technical rigour, diligence and stewardship is applied to material assessed and approved for release from such facilities. Crucial in developing and maintaining confidence is transparency. Careful collection and recording of radiological characterization and survey data, inventory management, documentation and control, and the regular communication of programme status and accomplishments will provide this transparency and is critical to a successful material clearance programme in the long term. A systematic approach using automated data collection and management systems along with standard reports and regular outreach meetings can be effective in meeting this challenge.

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THE VIEW OF THE STEELMAKERS

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Abstract

Since 1982 there have been more than eighty reported instances of radioactive material being accidentally melted during steel production. There is also evidence of unreported melting incidents. Steel makers have made considerable efforts to prevent such incidents, but they are continuing to occur, and steel makersalone will not be able to eliminate the problem. The root cause is inadequate control of radioactive sources. The European Union has accordingly introduced a Directive requiring improvements in control. However, this Directive only applies to the larger radioactive sources, and does not include all those that concern the steel maker. The Directive does offer some assistance to finders of orphaned radioactive sources. Monitoring systems are used to find radioactive sources that have entered the scrap recycling process. But, these systems have technical limitations and cannot be guaranteed to detect every radioactive source in the scrap. These technical limitations can be minimized by monitoring the scrap more than once during its progress through the scrap supply chain to the steel plant. Scrap processors therefore have a role to play in eliminating the problem of accidental melting of radioactive sources. The financial burden arising from the problem of inadequately controlled radioactive sources has unfairly fallen on the steel industry, rather than on the users of radioactive sources.

1. INTRODUCTION

1.1. Eurofer

The European Confederation of Iron and Steel Industries (Eurofer) was founded in 1976 to represent the steel industries of Europe. All producers in the European Union (EU) are members of Eurofer, and Switzerland and Turkey are associate members. The objectives of the organisation include cooperation in matters contributing to the development of the European steel industry. In particular, this involves providing the views and advice of the steel industry to the European Union. Eurofer represents its members on a range of technical and legal matters, but is not involved in commercial transactions. Radioactivity in steel scrap is a general problem for steel producers in Europe, so it is appropriate that Eurofer is involved in the issue.

1.2. The European steel industry

In 2007, the steel industry in the EU employed 370 000 people and produced 209 million tonnes of steel. More than 50% of this recycled steel scrap. Most of the scrap came from within the EU, but there were also imports of 5.8 million tonnes. In addition, there were exports of 10.8 million tonnes. Moreover 30 million tonnes of scrap was traded across borders within the EU. Steel scrap is a large and valuable business.

Scrap delivered to the steel plants is collected by scrap processing companies and is sorted and graded according to its physical nature and chemical composition. Additionally it is checked to ensure that it is free from hazardous materials and contaminants. The use of steel scrap to create new products is energy efficient and environmentally friendly, but there are inevitably problems in ensuring that quality is maintained. The problem of radioactivity in scrap was first recognizedrecognized in the 1980s, when radioactive material was accidentally melted during production of steel. Since then, considerable effort has been spent to minimize the problem. Unfortunately melting incidents still occur.

2. REPORTED MELTING INCIDENTS

Records of reported accidental meltings of radioactive material have been maintained by J. Yusko of the Pennsylvania Department of Environmental Protection, USA (see Fig. 1). Eighty per cent of all of the recorded meltings have involved the steel industry, but there have also been incidents in the production of aluminium, copper, zinc, lead, and gold.

Figure1 shows that melting incidents have been occurring since 1982. In the 1980s there was no checking of the products of the steelmaking process, and so the first detections of melting incidents occurred largely by chance. Twenty-seven years later, melting incidents are still occurring despite the fact that the problem is now well known, and considerable precautions are taken to prevent such incidents.

In fact, the statistics are probably being affected by the increased awareness of the problem, the better control of radioactive sources, and the more widespread monitoring of steel scrap. These factors would be expected to result in a decrease in melting incidents. There has also been an increase in the monitoring of the products of the steelmaking process, which makes it more likely that incidents that do occur will be detected.

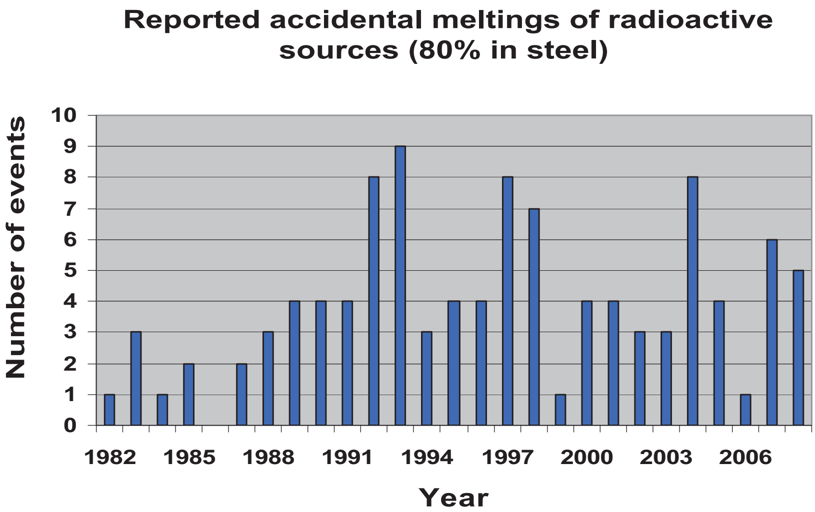

FIG. 1. Listing of reported meltings of radioactive material.

TABLE 1. POST STEEL PLANT DETECTIONS

Radioactive push buttons: France: October 2008 'Otis recall 500 lift buttons'	Radioactive watches: France: October 2000 'Radioactivity found in the bracelet'
Radioactive handles: Australia: October 2004 'Customs seize stainless steel drawer handles'	Radioactive wheel trim: United Kingdom: May 2000

3. POST STEEL PLANT DETECTIONS

Some melting incidents are still going undetected at steel plants, and the subsequent detection is dependant on monitoring systems in use elsewhere. The incidents listed in Table 1 appear to be concerned with amounts of radioactive material weighing a few kilograms. It should be realized that steel is typically manufactured in batches of 100 tonnes or more. It is likely therefore that the amount of radioactive material detected in these incidents is a small part of the total, and the remainder could still be in circulation, undetected.

There is now an increased checking of products before they leave steel plants, so the chances of radioactive products reaching the marketplace is becoming much lower. This monitoring is not universal, however, and if there is not routine monitoring of the products at the steel plant then the chances of detection of a melting incident are less.

4. MELTING INCIDENTS ARE UNDER-REPORTED

Before a melting incident can be reported it must be detected, which implies there is checking of the products of the process. There are three main products of the steelmaking process: steel; off-gas dust; and slag. In Europe, it is normal practice to check the steel produced. The commonly used radioisotopes cobalt-60 and iridium-192 partition to steel. Most steel plants will also check the off-gas dust, which is the material that becomes contaminated if caesium-137 is melted. Routine checking of the slag is less commonly done, and yet it is the material affected by the commonly used radioisotope americium-241. All the other actinide radionuclides, and radium also partition to the slag. Examination of the data shows that few melting incidents are reported in which these radioisotopes have been involved, and yet americium-241 is used as widely as cobalt-60 and caesium-137. The incidents involving americium-241 that have been reported all come from a limited number of sites that are known to monitor slag routinely for radioactivity.

There is inevitably a reluctance to report the melting of radioactive material; it causes disquiet among customers and the public. The public is concerned even if the incident has been well controlled and the entire radioactivity has been retained on site. The concern is magnified because the reporting is not always objective.

5. COSTS

The accidental melting of a radioactive source exposes people within the steel plant to radiation. If the melting is not discovered it may also expose the users of the contaminated steel. The costs arising from a melting incident can exceed one million euros, and for some incidents the costs have exceeded ten million euros. This cost is associated with the cost of decontamination, the cost of loss of production while the decontamination is in progress, and the cost of disposal of the waste created.

To protect against these problems the steel plants and some scrap suppliers have installed detection systems at a cost of 50 000 euro per unit. Each unit has annual running costs and maintenance costs, and it also creates nuisance alarms. In fact, most of the alarms are nuisance alarms that arise from low level naturally occurring radioactivity present in the scrap. Such alarms are inevitable because of the need to make the detector systems as sensitive as possible. Every alarm has to be investigated, and only when the investigation has been completed and the associated costs incurred, is it clear that it is a nuisance alarm.

The cost of correct disposal of a radioactive source can be around 10 000 euros.

6. CONTROL OF RADIOACTIVE MATERIAL

The origin of the problem is poor control of radioactive material. Nothing has changed in this respect. It should not be a problem for the steel industry. The main responsibility remains with the owners of radioactive sources. There is also a responsibility on the scrap processors to supply scrap free from radioactivity according to the European scrap specification (for discussion of this topic see the paper of R. Bartley in Session 5 of this conference).

In most countries there are legal controls on radioactive sources. The main problem has been enforcement of these controls. In Europe, the need for improved enforcement was recognized, and the HASS Directive was introduced in 2003 [1]. The Directive requires closer control of large radioactive sources. This is helpful to the steel producers but is an incomplete solution. HASS does not include the numerous smaller sources that could also cause serious contamination if accidentally melted in a steel plant.

HASS also offers help to the finders of orphan sources to encourage orphan sources to be declared and so be brought back under regulation. This is potentially highly beneficial in revealing orphan sources and ensuring their safe disposal. In the UK, however, the incentive for scrap processors and steel plants, to declare orphan sources does not exist, despite the HASS Directive.

Radioactive sources in use in countries outside the European Union are subject to the national legislations of those countries. The degree of control inevitably varies from country to country. There is some indication, although it is not quantifiable, that there is a higher incidence of radioactivity in scrap coming from these countries.

7. DETECTION SYSTEMS

There are a number of commercially available detection systems. They all detect gamma radiation and some also detect neutrons. The typical system is used to monitor incoming scrap loads on road vehicles. There are also systems that can be used to monitor rail wagons and systems that can be attached to grabs.

In Europe, the first detector systems were installed in the late 1980s. It is now normal for steel plants to monitor incoming scrap for radioactivity, and it is likely that all large steel plants have detector systems.

Among scrap processors, the situation is less consistent. In the UK, some scrap processors monitor for radioactivity; but others do not. The reasons for not monitoring are: the costs and a belief that it is unnecessary, since the steel plants will do the monitoring. The costs comprise: the cost for installation and maintenance of the monitoring equipment, and in addition, in the UK, the processor might have to pay the cost for the disposal of any radioactive material found.

Overall, there are benefits if the scrap processors monitor the scrap when it is delivered to their sites because if the scrap is monitored at that time and also when it arrives at the steel plant, the probability of detection of radioactive material is significantly increased. In addition, there is a better possibility of identifying the origin of the radioactive material because the scrap processor is earlier in the supply chain and closer to the original supplier. The scrap that reaches the steel plant is often material from several sources, and so the origin is less readily identifiable.

In the Netherlands it has been a legal requirement since 2003 to have detection systems in place for steel plants and for scrap processors handling more than 20k tonnes of scrap per year. There are indications that this has been effective in enabling radioactive material to be found before it reaches the steel plant.

Finally, there are technical limitations to detection systems. The systems are required to process large tonnages of scrap in a short time. The conditions are not ideal, and the detection of all radioactive material present in the scrap cannot be guaranteed.

8. IS IT RADIOACTIVE?

The European steelmakers publish a specification for scrap, which requires that scrap should be free from ‘radioactivity in excess of the ambient level’ (see paper of R. Bartley in Session 5 of this conference). A responsibility is therefore placed on the suppliers of scrap to monitor scrap and ensure that this requirement is met.

Typical clean steel has an activity of below 0.1 Becquerels per gram. Clean steel scrap is therefore a material that is inherently very low in radioactivity. Any alarm indicating the presence of radioactivity is a cause for concern and has to be investigated. It is an unfortunate practical consequence that most of the alarms investigated can be called nuisance alarms; the associated incident presents little or no significant hazard. They are caused by small amounts of naturally occurring radioactive material adhering to the scrap. The most typical find is a piece of pipework containing an internal deposit of naturally occurring radioactive material.

There has been much discussion about clearance levels and the level of radioactivity at which material can be released without further controls. There is a potential difficulty in that scrap metal that has been cleared might still contain sufficient radioactivity to trigger the alarm of systems monitoring steel scrap.

Whether this occurs will depend on the clearance level that has been applied. If an alarm occurs then the there is no choice but to search the load, and it might be rejected because it causes an alarm, despite the fact that it has met agreed clearance levels. It has been suggested by those studying the issue of clearance that the problem could be solved by prior notification that the scrap is cleared material. This might be possible, but it should be recognized that steelmakers will not readily accept material that is radioactive according to the installed detector system, and this will be true even if the cause of the alarm is known to be cleared material.

9. IF RADIOACTIVITY IS DETECTED

Detection of radioactivity in scrap does not usually cause an emergency situation. If the load containing the radioactivity can be isolated then the hazard to people is negligible. Isolation of radioactive material from scrap requires expertise and equipment but it is not usually difficult or hazardous.

In the UK, it is the responsibility of the finder to isolate the radioactive material. Thus, a quick response is usually possible if the expertise is available. In the Netherlands, and some other countries, it is the responsibility of the national authorities. This has the potential to slow down the response, but there is usually extensive expertise available.

10. CONCLUSIONS

The control of radioactive sources is still a problem. The steel industry is the main finder of orphan radioactive sources; it pays for detection and it pays for melting incidents. Users of radioactive sources do not bear the burden of cost for the problem.

REFERENCES

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THE RELEVANCE OF METAL RECYCLING FOR NUCLEAR INDUSTRY DECOMMISSIONING PROGRAMMES

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Abstract

The large amount of scrap metal arising from the decommissioning of nuclear facilities may present significant problems in the event that the facility owners seek to implement a management strategy based largely or fully on disposal in dedicated disposal facilities. Depending on whether disposal facilities currently exist or need to be developed, this option can be very expensive. Also, public reluctance to accept the expansion of existing disposal facilities, or the siting of new ones, mean that the disposal option should be used only after a wide consideration of all available management options. A comparison of health, environmental and socio-economic impacts of the recycling of lightly contaminated scrap metal, as compared with equivalent impacts associated with the production of replacement material, suggests that recycling has significant overall advantages. With present-day technologies, a large proportion of the metal waste from decommissioning can be decontaminated to clearance levels because most of the contamination is on or near the surface of the metal. In purely economic terms, it makes little sense for lightly contaminated scrap metal from decommissioning, which tends to be of high quality, to be removed from the supply chain and replaced with metal from newly-mined ore. In many countries, the metal recycling industry remains reluctant to accept metal from decommissioning. In Germany, the recycling industry and the decommissioning industry have worked together to develop an approach whereby such material is accepted for melting and the recycled material and is then used for certain defined end uses. Sweden also uses dedicated melting facilities for the recycling of metal from the nuclear industry. Following this approach, the needs of the decommissioning industry are being met in a way that also addresses the needs of the recycling industry.

1. INTRODUCTION

The decommissioning of nuclear power plants leads to the generation of significant volumes of metallic materials, much of which is only lightly radioactively contaminated. It comprises carbon steel in the main part, together with stainless steel and non-ferrous metals. A typical 1000 MW(e) boiling water reactor may contain up to 15 000 tonnes of metal, about half of which is very lightly radioactively contaminated, or uncontaminated, and can be readily prepared for free release in accordance with international norms. Much of the remaining material, which is largely associated with the primary circuit, could in principle also be decontaminated using currently available methodologies making this also suitable for conditional or unconditional release [1].

It is estimated by the OECD's Nuclear Energy Agency (NEA) [2] that about 400 commercial nuclear power plants will be decommissioning between now and 2050, which may result in more than 5 million tonnes of scrap metal suitable for recycling. Taking account of all other types of nuclear installation that will also be decommissioned, the amount of scrap metal available from nuclear decommissioning in the coming decades has been estimated to be as high as 30 million tonnes [3]. From Germany alone, the quantity of scrap metal available for clearance during this period will be in the order of several hundred thousand tonnes. [4]

Currently operating and planned waste facilities may have difficulty accommodating such large volumes of metal waste; e.g. for reasons of cost and because of public opposition to the expansion of available waste capacity or to the siting of new facilities. Legal requirements in some countries also generally favour recycling of metal waste over its disposal. The inherent value of these materials and the need to reduce waste directed to radioactive disposal facilities — especially when very low level waste facilities are not available — makes recovery through some form of decontamination an important consideration for the owners of nuclear facilities. Furthermore, recyclable materials sent to waste facilities must ultimately be replaced with new materials. Decision makers also

TABLE 1. ESTIMATED MATERIALS (IN TONNES) FROM DECOMMISSIONING FORSMARK UNIT 3 (1000 MW(e) BWR, SWEDEN) [1]

Radioactive material (tonnes)		
Reactor pressure vessel	760 (metal)	
Other contaminated systems	5950 (metal)	
Concrete	1230	
Sand	1050	
Operational waste	400	
Inactive/decontaminated material (tonnes)		
Metal	7700	Includes about 3000 tonnes from the steam turbines
Concrete	229 500	

need to bear in mind the adverse health and environmental impacts from mining and milling processes associated with the replacement of these materials as compared to the cost and other impacts from metal recycling.

2. DERIVATION OF CLEARANCE LEVELS

2.1. The radiological concepts of clearance and exemption

The concepts of clearance and exemption are closely linked — both require that the resulting radiation exposure is trivially small; i.e. the effective dose expected to be incurred by a member of the general public should be in the order of 10 μSv or less in a year and the collective dose should be less than about 1 man-Sv. Exemption means the determination by a regulatory body that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure (including potential exposure) due to the source or practice is too small to warrant the application of those aspects. Clearance is the process by which radioactive materials from a licensed practice are removed from further regulatory control. Thus, clearance involves the relinquishment of regulatory control, whereas exemption means that no regulatory control is applied to the relevant practice from the outset.

The exemption levels for radionuclides published by the IAEA in the International Basic Safety Standards [5] and contained also in the European Council Directive on basic safety standards (Directive 96/29/May 1996) [6] reflect an international consensus. The established levels apply to moderate amounts of material, e.g. in the order of 1 tonne, and thus the same levels cannot generally be used for clearance because substantially greater amounts of material will often be involved.

In deciding to release materials from regulatory control, regulators may allow clearance without conditions, i.e. unconditional clearance, or may allow clearance provided the materials are used for a specific purpose. In the case of the former, the cleared materials are subject to no further control and can be treated, recycled or reused for any other purpose. In the case of the latter, conditions are applied by the regulator which will have to be fulfilled before the material is released from regulatory control. This may mean, for example, that scrap metal has to be melted prior to further use, or that specified end uses of the recycled material are specified, or that cleared material has be transported to conventional disposal sites.

2.2. Clearance options for metals

The following clearance options for metals and other solid materials can be distinguished:

- Unconditional clearance of metals for direct reuse, recycling or eventually disposal;
- Clearance of metals for melting in a conventional foundry and then unrestricted reuse (i.e. not for direct reuse);
- Clearance of metals for melting in a specialized foundry and then reuse subject to restrictions (e.g. reuse in the nuclear industry).

Unconditional clearance options are addressed in the European Commission (EC) RP 122 Part I [7] and in IAEA RS-G-1.7 [8]. The various options for metal recycling are covered by EC, RP 89 [9].

2.3. Clearance levels

Clearance levels that have been calculated for the optiuons presented above are summarized in Table 2 for a set of radionuclides [10]. These radionuclides are relevant in reactor and fuel cycle facilities and represent various groups of nuclides, such as weak beta emitters (^{3}H, ^{14}C, ^{63}Ni), strong beta/gamma emitters as activation and fission products (^{60}Co, ^{137}Cs), strong beta emitters (^{90}Sr), and alpha emitters of different origins (^{235}U, ^{241}Am, ^{239}Pu).

The first two rows of Table 2 relate to unconditional clearance from the two recommendations RP 122 Part I of the European Commission [7] and RS-G-1.7 of the IAEA [8]. Both publications contain a set of rounded clearance levels that

TABLE 2. OVERVIEW OF CLEARANCE LEVELS FROM INTERNATIONAL GUIDANCE DOCUMENTS

Purpose	^{3}H	^{14}C	^{63}Ni	^{60}Co	^{137}Cs	^{90}Sr	^{235}U	^{241}Am	^{239}Pu	Unit
Unconditional clearance, RP 122/Part I [7]	100	10	100	0.1	1	1	1	0.1	0.1	Bq/g
Unconditional clearance, RS-G-1.7 [8]	100	1	100	0.1	0.1	1	—	0.1	0.1	Bq/g
Metal scrap for recycling or reuse, RP 89 [9]	1,000	100	10,000	1	1	10	1	1	1	Bq/g

are based on different scenarios and assumptions, but resulting in quite similar values. RS-G-1.7 has a slightly more conservative tendency. The third row of Table 2 provides the clearance levels from RP 89 [9] for metal scrap for melting. In comparison with the values from [7] and [8], they are generally the same or larger, indicating that a smaller and therefore less restrictive set of scenarios has been used.

A comparison of the numerical values from different countries is provided in Table 3. The differences in sets of clearance level values result from different assumptions in the models used, e.g. reflecting national or regional circumstances, including specificities of the material cycle, transport distances and industrial safety requirements. These factors influence the choice of scenarios and scenario parameters in the radiological scenarios and, therefore, the calculated clearance levels.

It is evident that some convergence of the models and values has occurred over the past 5 to 10 years and that the remaining differences are not significant, e.g. the clearance levels for key radionuclides such as ^{60}Co, ^{137}Cs, ^{90}Sr, ^{241}Am are of the same order of magnitude. This is the case, for example, for German levels for unconditional clearance and those of the EC RP 122 part I [7] and the IAEA RS-G-1.7 [8].

TABLE 3. OVERVIEW OF MASS SPECIFIC CLEARANCE LEVELS FOR ANY TYPE OF CLEARANCE OR FOR CLEARANCE OF METALS (IN Bq/g)

Country	^{3}H	^{14}C	^{63}Ni	^{60}Co	^{137}Cs	^{90}Sr	^{235}U	^{241}Am	^{239}Pu	Origin
Belgium	100			0.1	1	1	1	0.1	0.1	[7]
Finland	10	10	10	1	1	1	0.1	0.1	0.1	Nat. Regs.
Germany	1000 1000	80 80	300 10 000	0.1 0.6	0.5 0.6	1 9	0.5 0.8	0.05 0.3	0.1 0.2	Nat Regs.
Japan	100	1	100	0.1	0.1	1	—	10	0.1	[8]
Netherlands	10^6	10^4	10^5	1	10	100	10	1	1	[6]
Spain	100 1000	10 100	100 10 000	0.1 1	1 1	1 10	1 1	0.1 1	0.1 1	[7, 9]
Sweden	0.5 Bq/g for beta/gamma emitters						0.1 Bq/g for α-emitters			
*For ingots**:*	1000	100	10 000	1	1	10	1	1	1	[9]
UK	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	Nat. Regs.
USA*	530	310	21 000	0.2	0.6	18	0.7	0.2	0.3	Nat. Regs.

An overview of the national amounts of metals to be cleared is given in Table 4. It should be noted, however, that the data from different countries are based on different premises: in countries where no decommissioning projects are yet carried out, the figures refer to estimates of the *total* masses to be treated in the future. In countries where reference is made to a specific decommissioning project, the figures refer to that *particular project*. In countries with a generic approach with many ongoing decommissioning projects, the figures refer to the average *annual* masses to be subjected to a formal clearance procedure.

3. ALTERNATIVES TO CLEARANCE (RECYCLING, DISPOSAL AVLLW, INTERIM STORAGE)

3.1. General

In many countries, clearance is not considered a viable option for all or part of the material originating from the nuclear sector, e.g. for the large amounts of

TABLE 4. OVERVIEW OF METAL QUANTITIES TO BE CLEARED

Country	Metals	Comment
Belgium	726 tonnes: (79% of total mass) 2390 tonnes (95% of total mass)	Eurochemic reprocessing plant BR3 RR
Finland	N.A.	No decommissioning project exists
Germany	Several thousand tonnes per year	Annual amount for formal clearance procedure from various decommissioning projects
Japan	Clearance to be used for NPPs e.g. 30 000 tonnes for 1100 MW(e) BWR	
Netherlands	Clearance to be used for NPPs — several thousand tonnes *in total*	NPP Dodewaard only (clearance after 40-year safe enclosure)
Spain	7500 tonnes ferrous scrap in total 86 tonnes non-ferrous scrap in total 370 tonnes other materials in total	Vandellòs I NPP (clearance after 25-year safe enclosure)
Sweden	Metal scrap: 53 tonnes for recycling 119 tonnes for melting at Studsvik in total	For ACL and ACF facilities
UK	~10 000 m³ for disposal *in total*	Winfrith site only
USA	Case by case approach	Decision by NRC based on 'very low amounts' of radioactivity

material arising from decommissioning of nuclear installations. In these cases, other waste management approaches need to be applied, instead of, or in addition to, clearance. These include:

- — Recycling in the nuclear sector;
- — Disposal of (otherwise clearable) material, particularly building rubble and sand, as very low level waste (VLLW) on specific disposal sites;
- — Interim storage for decay.

Facilities for dealing with lowly contaminated radioactive material include specialised metal foundries in Germany and Sweden for melting scrap metal — which offer the possibility of subsequent recycling within the nuclear sector (as in Germany). Specific disposal sites for VLLW have been developed in France and in Spain and are under consideration elsewhere. The reasons for such an approach may be economic, technical or social, as further discussed.

3.2. Technical factors

Although technically feasible, demonstrating compliance with clearance levels may not be straightforward in all cases, especially for nuclide vectors with high abundances of hard to measure nuclides. An example for such material is metal scrap from fuel cycle installations with varying nuclide vectors where the effort for characterization and measurements can be substantial. In such cases, it may be much easier to use alternative methods such as melting in a dedicated foundry for which the necessary effort for characterization is significantly smaller.

A number of decontamination techniques exist that provide the means to recycle and reuse radioactive scrap metals [3]. A particularly important methodology is melting. During the melting process, ^{137}Cs volatilises from the metal. In most reactor scrap metal, the remaining radioactive elements have short half-lives (e.g. ^{60}Co), permitting material to be reused at some predetermined time in the future. Melting also results in considerable volume reduction and permits more accurate measurements of radioactivity.

Although melting is one of the main methods used in recycling practices, other techniques are available that permit items to be reused. These include decontamination by wet and dry blasting techniques, as well as chemical processes. A single technology may not be sufficient for decontaminating to below required clearance levels and, consequently, decontamination is frequently implemented in stages. The use of some processes is limited by the geometry of the surfaces and the difficulty in gaining access to the affected area, e.g. electrochemical decontamination processes are inappropriate for complex geometries, such as those on piping valves.

3.3. Health, environmental and socio-economic impacts

Two main options are available for managing the disposition of radioactive scrap metal; disposal and replacement, and recycling and reuse. Radiological risks to the public from both alternatives are typically at very low levels. In contrast, non-radiological health risks associated with disposal and replacement are much higher than those associated with recycling and reuse. This is due primarily to the potential for risks to workers from accidents associated with steel mill and blast furnace operations, and increased transportation risks due to new materials production.

Environmental and socio-economic impacts attributable to disposal and replacement exceed those for recycling and reuse. Land use, disruption and environmental damage from mining operations and the environmental impacts associated with the additional energy requirements of replacement processes are two of the many contributing factors. Environmental impacts associated solely with the disposal and replacement alternative also include the leaching of heavy metals from soils and mining waste into surface and ground water, and sedimentation of streams and rivers. Economic factors, including the effects of recycling on scrap metal markets, tend to favour recycling and reuse management alternatives.

However, both alternatives are often opposed by the public. The recycling and reuse of metals from the nuclear industry is perceived negatively by the public in many countries, while the siting of radioactive waste disposal facilities often faces public opposition.

4. CASE STUDY: GERMANY

4.1. Background

With the introduction of radiation portal monitors at the entrance gates of German scrapyards, steel works, foundries etc, in the late 1980s and in the 1990s, the problem of radioactivity in scrap, mainly steel and iron scrap, has come to the attention of the scrap and steel industry. The wide awareness that radioactivity may be present in scrap has led the scrap industry to suspect that the clearance of metallic materials from nuclear installations is one of the main sources of radioactivity in scrap and eventually in metal products. This in turn has caused scrap dealers to be reluctant to enter into contracts with the nuclear industry concerning material originating from decommissioning projects, regardless of the actual activity present on or in the material. The clearance of metal scrap, however, remains the backbone of materials management in nuclear decommissioning projects.

4.2. Situation in Germany concerning metal scrap from nuclear installations

The situation in Germany with respect to decommissioning of nuclear installations is characterised by the facts shown in Table 5 [11]. The nuclear power plants in decommissioning are the main source of metal scrap (as well as of building rubble and other materials which are outside the scope of this paper). A rough estimate of the total amount of metal scrap that has already been cleared or will arise over the next decades from all nuclear installations in Germany is on the order of a few 100 000 tonnes. This figure underlines the importance of clearance for the materials management, as it would be impossible to dispose of such material in a repository for low and intermediate level waste (LILW), because of the large volumes, or in (conventional) landfills, as the regulatory framework for conventional waste prescribes recycling.

4.3. Situation in Germany concerning recycling of metals

The monitoring of scrap and metal products as well as waste has been widely implemented in Germany. Even small radioactive sources can be safely detected in scrap loads. Procedures are in place for the interaction of the owners/managers of scrapyards, foundries, steelworks etc. with the authorities - concerning when to report incidents and how then to proceed depending on the measured dose rate.

Trade associations from the metal recycling industry, the steel industry and the non-ferrous metal producers have prepared position papers and a coordinated opinion, which may be summarized as follows:

TABLE 5. OVERVIEW OF NUCLEAR INSTALLATIONS UNDERGOING DECOMMISSIONING OR FULLY DECOMMISSIONED IN GERMANY [11]

Type of installation	In the process of decommissioning	Fully decommissioned or released from control
Reactors with electrical power generation (incl. prototype reactors)	17 reactors	2 reactors
Research reactors ≥ 1 MW thermal power (incl. nuclear ship Otto Hahn)	8 reactors	1 reactor
Research reactors < 1 MW thermal power	1 reactor	26 reactors
Fuel cycle facilities (primarily commercial production and reprocessing of fuel assemblies)	2 facilities	4 facilities

— Any radioactivity should be prevented from entering metal scrap, in order to assure the safety of the personnel and the general public, as well as to prevent contamination of foundries or steelworks.
— The criterion for deciding whether a scrap load contains radioactivity is linked to the dose rate that is measured at the outside of the load. Any dose rate above background levels is regarded as an indication of radioactivity. Contracts with the vendors of scrap usually contain clauses stating that the presence of radioactivity represents a failure to comply with the contract and that such a load must be taken back or that the cost of removal/disposal of the activity must be paid by the vendor.
— It is feared that continuous melting of cleared material will gradually increase the background activity level in the steel pool and that eventually the activity in products will be detectable. This would represent a major problem for manufacturers of cars or other metal products.

4.4. Solutions satisfying the interests of both parties

Currently, metal scrap from nuclear installations is accepted only by some scrap dealers and recycling companies. Those who accept the scrap usually appreciate the high quality and the absence of residues. The level of residual activity on, or in, the scrap also plays an important role. There are two clearance options for the recycling of metal scrap in Germany:

— Unconditional clearance (the material may be used for any purpose, including direct reuse, melting or disposal);
— Clearance for melting only (it must be guaranteed that the material is delivered to a foundry or steelworks and is melted there, so that direct reuse is prevented).

The clearance levels for the two options are different. For example, the clearance level for ^{60}Co, the most important radionuclide in steel, is 0.1 Bq/g for unconditional clearance, while it is 0.6 Bq/g in the case of clearance for melting. Both values are laid down in the German Radiation Protection Ordinance and correspond to the values in RP 89 [9] and RP 122 Part I [7].

The use of the 'clearance for melting' instead of 'unconditional clearance' has several advantages for the operator of the nuclear installation, for example, there is less effort for decontamination, easier measurement procedures, and fewer radionuclides to take into account. As the direct reuse of cleared material is rarely applicable, melting will almost always occur. The only problem is that a scrap load cleared, for example, on the basis of measurements at 50% of the higher release values (for ^{60}Co: 0.3 Bq/g) can be detected in radiation portal monitors, while a scrap load with measurements at 50% of the lower values (for ^{60}Co: 0.05 Bq/g) will not cause an alarm. In the first case, a load would be rejected, while in the second case, it would be processed.

This is the background to the approach followed by the nuclear industry in Germany. Contracts have been established between individual decommissioning projects (for which clearance using the higher clearance levels is of importance) and recycling companies and scrap dealers, by which the latter accept the cleared material and guarantee its subsequent melting. The competent authorities control this procedure by inspection of the contracts and by random checks of the melting process. In this way it is ensured that the higher clearance levels will in general only be used for material for which the destination is known and for which melting can be guaranteed. It can be assumed that clearance of metal scrap will in this way remain a viable option that is also accepted by the metal industry.

5. CONCLUSIONS

Clearance has emerged as an important option for the management of material from the decommissioning of nuclear installations over the last two decades. Extensive experience is available from dozens of decommissioning projects worldwide.

The clearance of materials is a decision normally taken for economic and/or logistical reasons.

- In cases where *no repository is available*, the decommissioning material requiring treatment as radioactive waste has to be segregated from the large quantities of material that could be reintroduced into the normal material cycle, i.e. cleared. Without clearance, interim storage capacities would have to be built to accommodate the large quantities of material, thus the overall cost of material management can be reduced significantly by the use of the clearance concept.
- In cases where *a repository is available* or where a repository is planned and (preliminary or final) repository acceptance criteria exist, clearance is often still the less expensive option. The costs for conditioning and packaging into waste containers suitable for the repository and the costs of disposal may significantly exceed the costs for segmenting, decontamination and clearance.
- Disposal in very low level waste repositories (where these are available) has economic advantages where large amounts of material have to be handled, though the economic benefits have to be balanced against the

social and environmental costs associated with the re-mining of metal ore to replace the metal lost in buried scrap.

Currently, it may not be possible to dispose of such large volumes of metal waste in operating and planned waste facilities, e.g. for reasons of cost and because of public opposition to the expansion of available waste capacity or to the siting of new facilities. Legal requirements in some countries favour the recycling of metal waste rather than its disposal. The inherent value of these materials and the need to reduce waste directed to radioactive disposal facilities makes recovery through some form of decontamination an important consideration for the owners of nuclear facilities. Furthermore, recyclable materials sent to waste facilities must ultimately be replaced with new materials. Decision makers also need to bear in mind the adverse health and environmental impacts from mining and milling processes associated with the replacement of these materials as compared to the cost and other impacts from metal recycling.

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THE GLOBAL NUCLEAR SAFETY REGIME APPLIED TO THE CONTROL AND MANAGEMENT OF INADVERTENT RADIOACTIVE MATERIAL IN SCRAP METAL

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Abstract

The paper details the various elements of the global nuclear safety regime that can be utilized to better control and manage the presence of inadvertent radioactive material in scrap metal.

1. INTRODUCTION

The consequences of radioactive material, inadvertently present in scrap metal, being melted are serious, mainly for economic reasons. The global nature of the metal recycling industry and difficulties in resolving the problem make this a significant challenge. There are two main types of radioactive material that are found in scrap metal. The first type is orphan radioactive sources that have been lost from, or never were, under regulatory control. The second type is radioactively contaminated metal which may occur in a number of ways, the most likely being from the demolition or decommissioning of facilities that have used radioactive material. This material could be contaminated by artificial or natural radionuclides depending on its origin.

A large portion of the scrap metal that is consumed is traded internationally, and may therefore originate in one country and be transported large distances before being processed in another. In view of this international dimension, operators of nuclear facilities, regulators, the scrap metal recycling industry and other stakeholders have clearly expressed the need for the development of a harmonized approach to preventing radioactive sources and other radioactive material from being unintentionally introduced into metal scrap and for dealing with such situations should they occur.

There has been a growing awareness in recent years that sealed radioactive sources, in particular, may be attractive to those with malicious intent and, as a consequence, that there might be clandestine trafficking in them. Such trafficking may lead eventually to radioactive sources becoming mixed with scrap metal. However, in general, the radioactive sources that find their way into scrap metal that is destined for recycling do not originate from such trafficking and, therefore, the intentional introduction of radioactive material into scrap metal is not discussed in this paper.

2. THE GLOBAL NUCLEAR SAFETY REGIME

The global safety regime provides an international framework for the protection of people and the environment from the effects of ionizing radiation. The main elements of the global safety regime are:

- A framework for achieving high levels of safety and for continuous safety improvement;
- The subscription by countries to intergovernmental agreements on safety — which helps to promote the pursuit of high levels of safety worldwide;
- A comprehensive, coherent and authoritative suite of universally accepted safety standards which embody the current best safety practices.

3. INTERNATIONAL AGREEMENTS

Some of the issues which arise in relation to the presence of radioactive material in scrap metal are addressed in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [1]. The Joint Convention was negotiated and agreed in the late 1990s and is now in force. The Contracting Parties to the Joint Convention have now held two review meetings which have identified areas where significant progress has been made, particularly in the establishment of holistic national waste management policies, including decommissioning activities, and in the management of legacy waste.

Among the obligations of Contracting Parties, Article 11 on General Safety Requirements stipulates that each Contracting Party shall take the appropriate steps to ensure that, at all stages of radioactive waste management, individuals, society and the environment are adequately protected against radiological and other hazards and take the appropriate steps to, ‘inter alia’, ensure that the generation of radioactive waste is kept to the minimum practicable and to take into account interdependencies among the different steps in radioactive waste management. This article sets out an obligation to recycle and reuse radioactive residues when it is possible and to include this management route as early as possible in activities in which radioactive material is used and produced.

To avoid the loss of control over sealed radioactive sources (and their further inclusion into scrap metal), the Article 28 on Disused Sealed Sources stipulates that each Contracting Party shall, in the framework of its national law, take the appropriate steps to, 'inter alia', ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.

As a development of Article 28, the Code of Conduct on the Safety and Security of Radioactive Sources [2] complements existing international conventions and standards in the area of control and management of radioactive sources. Through the development, harmonization and implementation of national policies, laws and regulations, and through the fostering of international cooperation, the Code aims to achieve and maintain a high level of safety and security of radioactive sources and to mitigate or minimize the radiological consequences of any accident or malicious act involving a radioactive source. These objectives should be achieved through the establishment of an adequate system of regulatory control of radioactive sources, applicable from the stage of initial production to their final disposal, and a system for the restoration of such control if it has been lost.

In the event of a radiological emergency, the Convention on Early Notification of a Nuclear Accident [3] and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [4] apply.

4. THE IAEA SAFETY STANDARDS

One of the functions of the IAEA, specified under Article III of its Statute, is to establish or adopt standards of safety for protection of health and minimization of danger to life and property and to provide for the application of these standards. In earlier times, the IAEA developed safety standards in response to the needs and requests of Member States. Over time, the need for a comprehensive and authoritative set of international standards in the areas of nuclear safety, radiation protection and radioactive waste management became more evident.

The present suite of standards has a three-level structure: Safety Fundamentals, Safety Requirements and Safety Guides. The Safety Fundamentals publication, the Fundamental Safety Principles [5] sets the scene for greater harmonization of the approach to safety across the whole spectrum of nuclear and radiation related technologies. Two principles are of particular relevance for the control and management of radioactive residues that can enter the scrap metal cycle. Principle 2 on the role of government requires that an effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained. As part of this, government authorities have to provide for control over sources of radiation for which no other organization has responsibility, such as some natural sources, 'orphan sources'[1] and radioactive residues from some past facilities and activities. Principle 7 on the protection of present and future generations requires that people and the environment, present and future, must be protected against radiation risks**.** One aspect of this is that the generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material.

4.1. Standards for practices

The Safety Requirements publication applicable to radiation protection and safety is the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [6]. The BSS establishes the 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. The BSS gives examples of the types of 'practice' to which it applies. These examples suggest that the inadvertent handling of orphan sources or radioactively contaminated material in the metal recycling industry need not be considered a 'practice' within the meaning of the BSS. In terms of the BSS, the discovery of a radioactive source or radioactively contaminated material should be regarded as a potential intervention situation, for which an appropriate emergency response is needed.

In the context of radioactive residues entering the metal recycling industry, the IAEA has developed several Safety Guides that are relevant to the recovery of control over orphan sources. In 2008, the IAEA issued an updated Safety Guide on the Classification of Radioactive Waste [7]. The updated Safety Guide provides for the classification of all radioactive waste types in a coherent manner and uses the clearance concept for identifying the boundary between waste that needs to be managed as radioactive waste and waste which can be removed from regulatory control for management as conventional waste.

Stringent controls over the management of radioactive residues are generally applied at licensed nuclear and other facilities. In this case, material can be released only after a clearance procedure has been applied in which it is demonstrated that the level of radioactivity in the material is below the clearance values permitted by the regulatory body. The IAEA has also provided guidance on the levels for exemption and clearance of bulk material from regulatory control [8].

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[1] An orphan source is a radioactive source that is not under regulatory control, either because it has never been under regulatory control, or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization.

4.2. Standards for intervention

Regulatory controls sometimes fail and the appearance of radioactive sources or other radioactive material in scrap metal destined for recycling or other purposes is an example of such failure. High activity radioactive sources that are present in scrap metal represent a major concern because of the potential for significant radiation exposures of scrap metal facility workers or members of the public. However, the levels of contamination that are likely to appear in finished products following the melting of metal with radioactive material will generally not be so high as to present an acute health hazard. In fact, the economic costs associated with the shutdown of facilities and remediation efforts may be more significant.

The procedures that regulatory bodies and operators of metal recycling facilities have to follow in preparing for and responding to an accident are detailed in the IAEA Safety Requirements, Preparedness and Response for a Nuclear or Radiological Emergency [9]. The preparedness step is a critical one and IAEA has published a Safety Guide on Arrangements for Preparedness for a Nuclear or Radiological Emergency [10].

Environmental remediation after accidental radioactive releases and the subsequent management of the radioactive waste can represent a substantial burden for the industrial operator. The concept of clearance as a means of minimizing the waste generated as a result of remediation activities may be valuable in this context [8]. Guidance on the remediation of metal recycling facilities that may become contaminated as a result of radioactive material in scrap metal is provided in the Safety Guide on Remediation Process for Areas Affected by Past Activities and Accidents [11].

4.3. Standards for radioactive waste management

Radioactive waste can result from the detection of radioactive contamination in scrap metal or from the cleanup of facilities affected by the melting of metal containing radioactive material. Proper radioactive waste management routes are then needed to ensure the protection of the public and the environment. Every country should have some form of policy and strategy for managing its radioactive waste. Such policies and strategies are important; they set out the nationally agreed position and plan for managing radioactive waste and are visible evidence of the concern and intent of the government and the relevant national organizations to ensure that radioactive waste is properly taken care of. In particular, every country should have identified the national organization that will collect, store and dispose of contaminated scrap, remediation waste and orphan sources.

The suite of publications within the IAEA Safety Standards Series devoted to radioactive waste management is now comprehensive and addresses all steps from predisposal management [12], to storage [13], and eventually to the various forms of disposal [14; 15].

4.4. A new safety guide on radioactively contaminated material in metal recycling

The successful implementation of the global nuclear safety regime should result in adequate control over radioactive material. However, the radiation and waste safety infrastructures within individual States may not be sufficiently well developed or may fail with the consequence that radioactive sources may be lost from control or that radioactively contaminated material may become mixed with scrap metal that is destined for recycling.

With this in mind, the IAEA is developing a Safety Guide that will provide recommendations to governments and the metal recycling industry on the detection and identification of radioactive material that may be inadvertently present in scrap metal, as well as actions to be taken following the identification of such material.

A partial listing of topics to be included in the Safety Guide is as follows:

— The application of the IAEA's Safety Requirements to the problems posed by the presence of radioactive material in scrap metal;
— Responsibilities of governments, regulatory bodies, and the metal recycling industry;
— Monitoring for radioactive material in scrap metal within the metal recycling industry;
— Response to detection of radioactive material in scrap metal;
— Remediation of contaminated facilities;
— Management of recovered radioactive material;
— Training of workers in the scrap metal industry;
— International cooperation;
— Review of incidents involving radioactive material in the metal recycling industry;
— Examples of national and international initiatives.

5. CONCLUSION

The global nuclear safety regime, when properly and fully applied, should prevent the occurrence of radioactive material in scrap metal. However, the evidence shows that such events occur and have been sufficiently numerous to encourage many metal recycling facilities and metal processing works to introduce measures to detect the presence of radiation.

The IAEAs suite of safety standards provides guidance for the management of many aspects of the radiological problems surrounding radioactivity in scrap metal but, in recognition of the fact that more specific guidance is needed; a new Safety Guide is being developed. Its primary focus will be on the detection and identification of radioactive material that may be inadvertently present in scrap metal, as well as actions to be taken following the identification of such material.

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EUROPEAN LEGISLATION TO PREVENT LOSS OF CONTROL OF SOURCES AND TO RECOVER ORPHAN SOURCES, AND OTHER REQUIREMENTS RELEVANT TO THE SCRAP METAL INDUSTRY

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Abstract

European legislation (Council Directive 2003/122/EURATOM) has been adopted with regard to the control of high-activity sealed radioactive sources (HASS). This Directive is now part of an overall recast of current radiation protection legislation. At the same time the main Directive, 96/29/EURATOM, laying down Basic Safety Standards (BSS) for the health protection of the general public and workers against the dangers of ionizing radiation, is being revised in the light of the new recommendations of the International Commission on Radiological Protection (ICRP). The provisions for exemption and clearance are a further relevant feature of the new BSS. The current issues emerging from the revision and recast of the BSS are discussed, in the framework of the need to protect the scrap metal industry from orphan sources and to manage contaminated metal products.

1. INTRODUCTION

The main focus of this paper is on European legislation to prevent the loss of sources and to recover orphan sources, in particular the EURATOM Directive [1] on the control of high activity sealed radioactive sources and orphan sources (Council Directive 2003/122/EURATOM). This Directive should be instrumental in preventing sources being incorporated in scrap metal and causing contamination. The term ‘contamination’ is defined in relation to the levels of activity concentration establishing the borderline of regulatory control: levels for exemption, below which materials are not subject to controls, and levels for clearance that allow materials to be released from regulatory control, in particular, materials arising from the dismantling of nuclear installations.

The paper will explain the relevant requirements of the HASS Directive and how they will be merged in a recast BSS Directive [2].

The existing legislation and its development as part of the recast process is a building block in the development of an EU policy with regard to the control and management of inadvertent radioactive material in scrap metal.

2. HIGH ACTIVITY SEALED SOURCES AND ORPHAN SOURCES

2.1. Background

In the 1990s there were several severe incidents involving lost sources all around the world (China in 1992, Georgia in 1997, Turkey in 1998, Peru in 1999). The incident which prompted the European Commission to propose new legislation took place in Algeciras, in the south of Spain in 1998, where a ^{137}Cs source was melted in a steel factory, causing contamination of the installation and the generation of large amounts of contaminated residues, as well as a significant economic detriment. The release of ^{137}Cs from the stack was detected as far away as France and Italy.

This event accelerated the development of specific legislation and its relatively fast adoption through Community procedures. The legislation was focused on the control of sources. It did not address the contamination of metal or scrap metal, a problem which has been encountered in later years, most recently in Europe through the detection of contaminated metal originating in China and India.

The developments did not extend to the security or physical protection of sources, which was regarded as a national responsibility, nor the security threat which stolen or orphan sources may represent. Since 11 September 2001, security has become a major concern, and the community is fortunate to have adopted legislation that happens to meet these concerns also.

Among the reasons for the loss of regulatory control over sources, the Commission identified the lack of adequate regulatory control at the time of supply of the sources and of traceability during the whole lifecycle of the source. Therefore, it was necessary to raise the awareness of holders of sources, in particular with regard to the need to manage sources that are no longer in use.

2.2. Council Directive

These considerations led the European Commission to propose specific legislation on the management of sealed radioactive sources, with a view to strengthening the control by the competent national authorities and emphasizing the responsibilities of holders of sources. In order to make the requirements effective and not to impose a disproportionate administrative burden for the control of tens of thousands of miscellaneous sources, the scope of the proposed Directive was restricted to those sources posing the highest risk (high activity sealed sources (HASS)) as well as to orphan sources. A source is considered to be a HASS source if its activity exceeds activity levels specified in an annex to the Directive. This definition does not fully match the IAEA classification of sources, which was established only after adoption of the Directive. Orphan sources are lost sealed sources above exemption values that may have been classified as HASS at the time of manufacture or delivery but which have since decayed to below HASS activity levels.

The Directive was promptly adopted by the Council in December 2003 (2003/122/EURATOM). While it contains stand-alone minimum obligations for the control of sources, these supplement the requirements of the BSS (Directive 96/29/EURATOM) "for the health protection of the general public and workers against the dangers of ionizing radiation". The BSS are the cornerstone of all community radiation protection legislation.

2.3. Recast of the BSS

The Commission is currently revising its BSS, in line with the latest recommendations of the International Commission on Radiological Protection (ICRP) [3], as well as with a similar revision being undertaken of the International Standards [4]. In addition to the revision of the BSS, the consolidation of all other Directives in a single document is being pursued as part of an overall policy of simplification of Community legislation, i.e., the Directive on medical exposures (94/43/EURATOM) [5], public information (89/618/EURATOM) [6], outside workers (90/641/EURATOM) [7], as well as the HASS Directive. The integration of the latter Directive has proven rather cumbersome. The process has highlighted the very specific features of this Directive, which include requirements such as financial provisions and penalties not included in other legislation. There is much more detail than in other Directives. The most specific detailed requirements will eventually be listed in an annex to the recast Directive, in particular with regard to record keeping, by the holder and by the authorities, of the inventory of sources and of any transfers, as well as the identification, marking and documentation of the sources in order to ensure their traceability in case of loss.

The requirements for the authorization of the holders of sources, defining responsibilities, minimum staff competencies, emergency procedures and communication, could be made applicable to any radiation source, not only sealed radioactive sources. Specific requirements, such as for the management of disused sources to be sent back either to the manufacturer or to a waste disposal site, as well as provisions by way of financial security for that purpose, again will be put in an annex. It should be noted that under the HASS Directive, the mere act of taking possession of a source is subject to authorization, whereas, in general, this applies to the undertaking making use of a radiation source.

The above requirements will, according to the current outline of the recast Directive, be incorporated in a Title on Justification and Regulatory Control of

Practices. The requirements for controlling the presence, integrity and transfer of sources belong to a title on Responsibilities for Regulatory Control. It is worth noting that, under the HASS Directive, training does not only relate to the protection of workers handling the source, but extends to the consequences of the loss of adequate control of the source.

Information and training should also be provided to the management and workers in installations where orphan sources are most likely to be found (e.g., large metal scrapyards or recycling plants) and in significant nodal transit points (customs offices), in order to enable them to take action in the event of detection of an orphan source. This puts a requirement on Member States and authorities with regard to installations that generally do not fall within the scope of regulatory control. Hence it was worded prudently as: "Member States shall provide encouragement so as to ensure that …".

The discovery of, or any incident resulting from, an orphan source should now be regarded as an 'emergency exposure situation', as defined in ICRP Publication 103 [3]. Competent authorities must be prepared to recover orphan sources and to ensure that a system of financial security is in place to cover intervention costs. Member States must also ensure that specialized technical advice and assistance is available to persons who suspect the presence of an orphan source. These requirements will be incorporated in the title on Emergency Exposure Situations of the recast Directive.

For a while, it was considered that the existence of historical orphan sources that could potentially emerge and cause exposure could be regarded as a special 'existing exposure situation', but eventually it was decided to keep all provisions relating to orphan sources together in the title on Emergency Exposure Situations.

Finally, Article 11 of the HASS Directive requires a prompt exchange of information and cooperation with other Member States, third states and international organizations as regards the loss, removal, theft or discovery of sources. For this purpose, Member States can use the urgent information exchange system established under Council Decision 87/600/EURATOM (ECURIE) [8]. Recently, this system, as well as the communication instructions agreed with the Member States, was broadened to allow the transmission of information messages in addition to actual emergency alerts. Messages of this type can be transmitted at any time on a 24 hour basis and do not require an immediate response by the receiving Member States. Over the past year, ECURIE has received two messages related to sources.

3. EXEMPTION AND CLEARANCE

3.1. Graded approach to regulatory control

Directive 96/29/EURATOM introduced the concepts of exemption and clearance. There is an important distinction between ‘exemption’ of practices or planned activities from the requirement of reporting and ‘clearance’, or the release of materials within controlled practices from further requirements. This distinction is now very well understood and clearance is an important part of dismantling policies. However, while exemption values were introduced on the basis of Radiation Protection RP-65 [9] (and endorsed internationally), no such values for clearance were available at the time of the adoption of the Directive.

In the new BSS, these concepts will be preserved. However, in order to align the terminology to the International Standards, use will be made of the concepts of ‘notification’ rather than ‘reporting’, ‘registration’ and ‘licensing’, rather than ‘prior authorization’, as part of a much more elaborate ‘graded approach’ to regulatory control.

An important element of this graded approach is that it makes provision for exemption both generically, on the basis of pre-established values, and for specific exemption by the regulatory authority (or as laid down in national legislation). Similarly, clearance can be granted by the regulatory authority either on the basis of default values for any type of material and any pathway of release or by the use of specific clearance levels. Such specific clearance levels have been defined for the recycling of scrap metal in RP-89 [10] and for the reuse of buildings or the recycling of building rubble in RP-113 [11]. General clearance levels were laid down in RP-122 [12] (part I for artificial radionuclides, part II for naturally occurring radionuclides).

3.2. Exemption and clearance levels

For the recast BSS, the original idea was to use the same set of radionuclide-specific values, both for general clearance and for exemption of unlimited amounts of material. Under the current BSS, and in EC guidance on clearance levels, it was felt that clearance levels always needed to be lower than exemption values in order to avoid ‘return loops’ in the system. Now the conceptual difference between exemption and clearance as well as the definition of ‘practice’ and of ‘undertaking’, which has legal responsibility for an activity of this type, has been made sufficiently clear so as to allow having the same values, without ambiguity.

Exemption values for unlimited amounts of materials are useful, e.g. in the context of scrap metal. The question arose as to whether it was useful to also keep the old exemption values, which were originally derived for ‘moderate amounts’.

A further issue was whether for general clearance the European Community would align with the international ‘scope-defining levels’ which, after years of discussion, were laid down in IAEA Safety Guide RS-G-1.7 [13], or whether EC’s guidance in Radiation Protection 122 was to be preferred.

Before deciding on this matter a study was launched [14] to check and explain the differences between RP-122 part I and RS-G-1.7 values, and also to look into the consequences of taking either set of numbers as generic values for exemption, e.g. of consumer goods.

It was found that, in general, the values in RS-G-1.7 are higher than those in RP-122, but the study has concluded that this was defensible. For the most important radionuclides, the values are the same. On the other hand, while the scenarios that led the IAEA to propose lower values for ^{14}C and ^{129}I have been found to be conservative, these values do not seem to be a problem either.

Nothing in the study suggests that using the RS-G-1.7 values as exemption values for activity concentrations would be problematic. Specific cases could, in any case, be dealt with under the regime for specific exemption. However, internationally, as well as in some EU Member States, some countries would like to preserve the old exemption values for moderate amounts, because much of the existing legislation has been built on these values, including the international transport regulations.

This is an important issue for contaminated material because, currently, the sole legal basis for restricting the import of such shipments is the exemption values. Maintaining a higher value for the activity concentrations for ‘moderate amounts’ of material may cause further legal uncertainty.

4. CONCLUSIONS

The revision of the BSS, both those of EURATOM and those of the international organizations, is progressing well but there is still much work ahead. The incorporation of the new rationale and concepts of ICRP Publication 103 is not easy. A forthcoming ICRP publication on the management of emergency exposure situations also needs to be taken into account. The full integration of artificial and natural radiation sources is not straightforward, either. Nevertheless, it is hoped that the work of the Article 31 Group of Experts on the revision will be concluded by the end of this year or by spring 2010. The Commission will then need to decide whether to present a new Council Directive or to use the recast procedure agreed upon between the European institutions (Commission, Parliament and Council), so that unmodified articles do not need to be discussed. So many modifications have been made already and quite a few requirements are now being put in a different perspective that it may be difficult to pursue the recast procedure.

The Directive on HASS and orphan sources is a good example of how requirements may end up in different titles and take on a more general meaning. This Directive was also found to have unique features with regard to safety or security matters, financial provisions and penalties. The requirements of the HASS Directive, now part of the overall BSS, will continue to play an important role in the safety and security of sources in the EU and the implementation of the Code of Conduct by the IAEA. For the sake of international harmonization, the Commission envisages introducing the classification of sources made by IAEA as well as agreeing internationally on the set of exemption and clearance values. One of the important issues that has to be resolved is the role of the old exemption values (for 'moderate amounts' and for transport).

The recast Directive will introduce a more flexible regime of regulatory control, proportionate to the issue and with more room for discretionary decisions by the competent authority. It is hoped that this will respond better to the needs of the scrap metal industry but it may not resolve all the problems. If necessary, further initiatives at the EU level will be considered.

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REGULATORY CONTROL OF RADIOACTIVE SOURCES IN SPAIN

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Abstract

The arrangements for the regulatory control of the safety and security of sealed radioactive sources in Spain are described. Emphasis is given to the situations which are most likely to result in the loss of control of sources and on the procedures introduced to reduce the likelihood of losses in these cases. Finally, the strategy for locating sources which have been lost from control (orphan sources) is described.

1. INTRODUCTION

Since its discovery late in the nineteenth century, ionizing radiation has been widely used throughout the world in the fields of medicine, industry, agriculture and research. Sealed radioactive sources containing long-lived radionuclides are used to produce ionizing radiation in many of these fields. When sealed sources are lost from control they are termed ‘orphan sources’. Experience in recent years has shown that orphan sources may find their way into metal scrap and be processed in metal industry factories with severe consequences.

2. SEALED RADIOACTIVE SOURCES IN SPAIN

A sealed radioactive source is radioactive material in a solid form that is permanently sealed in a metallic capsule. The capsule of a sealed source is strong enough to maintain leak-tightness under the conditions for which the source was designed, including foreseeable accidents. Radioactive sealed sources are usually incorporated within equipment and surrounded by a shielding housing that attenuates the radiation and provides protection for the user. As long as the sources remain sealed, the shielding remains intact and the devices are handled and used properly, the devices present no risk. Manufacturers of the devices must demonstrate that the source is secure and that users are adequately protected in order to receive a licence to manufacture and sell them.

In many cases, the presence of considerable amounts of metallic materials in these devices, having a high monetary value, makes them attractive to scrap collectors. The risk of them being collected as scrap is increased if they are lost from control and poorly marked.

If the entire equipment containing the radioactive source is lost from control, it is easy to recognise, provided that the marking and labelling, which is always present on such devices, has not been intentionally removed. In the case of a single, isolated sealed source, recognition is more difficult. Sealed radioactive sources can often look like small pieces of metal; the only certain way to visually recognize them is by their engraved radiation label (trefoil). Depending on the size of the source, it may also have the word 'radioactive' engraved on the source itself or its container.

The potential for orphan sources to end up in metal scrap varies widely in different countries. Without taking into account whether or not there is an effective regulatory control system in the country, the risk is related to the number of sealed sources used in the country. In the case of Spain, the following table summarizes the situation with respect to high activity sealed sources (HASS).

From Table 1, it can be seen that only a few radionuclides are used in these applications. ^{60}Co ($t_{1/2}$ = 5.3 years), ^{137}Cs ($t_{1/2}$ = 30 years) and ^{192}Ir ($t_{1/2}$ = 74 days) are present in most of the listed practices. Sealed ^{85}Kr sources are often used in industrial gauges (372 in Spain) but the radiological consequences in the case of a melt down are low as the radionuclide is gaseous in form.

In Spain, the main contribution to the total number of high activity sealed sources comes from sectors of industrial radiography and industrial gauging. Uses in medicine have been reduced due to the development of radiotherapy procedures using linear accelerators and in the last 15 years many teletherapy units using ^{60}Co sources have been decommissioned.

3. SAFETY AND SECURITY OF RADIOACTIVE SOURCES

Soon after the discovery of ionizing radiation, its harmful effects on humans were recognized together with the need for protection of users by appropriate regulation of all practices involving its use.

The principles for a system of protection and regulation of practices involving the use of radiation were established by the International Commission on Radiation Protection (ICRP) in 1959. Based on these principles, many countries developed regulatory systems for the safety and security of practices involving radiation. The systems allowed society to have benefits from the uses of radiation without undue risks. The principles defined by ICRP have evolved

TABLE 1. HIGH ACTIVITY SEALED SOURCES (HASS) IN SPAIN

Use	Radionuclide	Typical activities		Number currently in Spain
		Tera-Becquerels	Curies	
Thermoelectric generators	^{90}Sr	7.4E+02	2.0E+04	O
Irradiators used in sterilization and food preservation	^{60}Co	1.5E+05	4.0E+06	1
Self-shielded irradiators	^{137}Cs	5.6E+02	1.5E+04	1
Blood/tissue irradiators	^{137}Cs	2.6E+02	7.0E+03	19
Multi-beam teletherapy (gamma knife)	^{60}Co	2.6E+02	7.0E+03	1
Teletherapy	^{60}Co	1.5E+02	4.0E+03	42
Industrial radiography	^{60}Co	2.2E+00	6.0E+01	534
	^{192}Ir	3.7E+00	1.0E+02	
	^{75}Se	3.0E+00	8.0E+01	
Brachytherapy	^{60}Co	3.7E-01	1.0E+01	71
	^{137}Cs	1.1E-01	3.0E+00	
	^{192}Ir	2.2E-01	6.0E+00	
Industrial gauges	^{137}Cs	1.9E-01	5.0E+00	484
	^{60}Co	1.9E-01	5.0E+00	
	^{241}Am	2.2E-02	6.0E-01	
	^{85}Kr	3.7E-02	3.7E-02	

with time taking account of the evolution in the knowledge about radiation and its biological effects.

International organizations such as the IAEA and the European Commission have developed international standards and regulations, also based on ICRP recommendations, to help and support countries in developing their own regulations.

The development and operation of the system for radiation safety and security requires the creation and maintenance of appropriate national infrastructures. One of the most important elements of the infrastructure is the regulatory body which is in charge of the regulation, licensing and oversight of all practices involving radiation in the country. The system for the safety of activities using ionizing radiation has as a main objective: to protect people, goods and environment from the harmful effects of radiation, while allowing its beneficial uses.

In Spain, regulations to create a system for the safety of radiation applications were introduced early in 1964 and fully developed in 1972. It incorporates as main elements: a regulatory framework, the authorization of all activities involving radiation sources, the control of authorized activities, the control of the purchasing of radioactive sources, the management of disused sealed sources and the qualification and training of personnel.

The safety system currently in force in Spain is based on international approach defined in the IAEA International Basis Safety Standards [1] and in the EURATOM Directive [2]. A set of national laws and regulations has been developed, the most important of which are:

— Act 25/1964 on Nuclear Energy;
— Act 15/1980 Creation of Regulatory Body (CSN);
— RD 1836/1999 Nuclear and Radioactive Facilities Regulation;
— RD 783/2001 Radiological Protection;
— RD 1891/1991 Medical X ray Facilities.

These regulations are complemented by specific safety requirements included in operations permits required for each activity involving ionizing radiation.

The system for security of activities involving ionizing radiations has as a main objective: to protect people, goods and the environment from malevolent uses of nuclear and radioactive materials. It has been fully developed recently at an international level as a result of the concerns raised and the analysis performed after events on September 11, 2001 in the USA. In Spain, the system for the security of activities using ionizing radiations is still under development. The goal of the system is to avoid the access by non-authorized personnel to radioactive materials. Activities to be carried out within this system include: protecting facilities, activities and materials against sabotage and robbery, preventing and prosecuting radiological crime and terrorism, detecting and preventing illicit trafficking of radioactive materials and detecting the inadvertent movement of radioactive materials.

For the development of the system for security, the international approach has also been followed in Spain. The IAEA Code of Conduct on the Safety and Security of Radioactive Sources [3] and the European Directive EURATOM/122/2003 [4]on the control of high activities sealed sources and orphan sources, were used as the main references for the national system.

A regulation devoted to security matters for the specific case of sealed radioactive source in Spain has been issued: it is Regulation 229/2006 on the control of high activity sealed sources and orphan sources. This complements regulations in force related to generic security matters:

— Law 2/1986 of Security Forces;
— Law 1/1992 of Citizen Security;
— Act 23/1992 of Private Security;
— RD 2364/1994. Private Security Regulation.

4. CONTROL OF RADIOACTIVE SOURCES

The systems for safety and security of activities involving ionizing radiation include many provisions oriented to avoid situations of increased risk of loss of control which might cause sources to become orphaned. Typical situations of increased risk in the life of sources are: illegal purchasing or import, the long term storage of sources out of use, the existence of deficient safety or security provisions during operations and use, deficient safety during maintenance, inadequate management of mobile sources, lack of emergency planning, lack of qualified personnel in key positions, company crises, uncertainties about future uses and the availability of disposal fees at the time of facility decommissioning.

Control provisions exist within regulations to assure that radioactive materials are subjected to safety and security provisions from the time they are manufactured to the time they fall out of use, i.e. no further use is anticipated for them. After that time, they have to be stored in an authorized facility for the safe disposal of radioactive materials.

The first step to avoid sealed sources going out of control is the authorisation or licensing process. Spanish regulations require source holders to be authorized before sources are delivered by the supplier. The licence includes detailed descriptions of all sources allowed to be held by the facility. An inspection by the regulatory body inspectors is conducted before operations startup — to verify that the radioactive materials actually supplied match with those specified in the permit and to assure that the licensee is complying with all licence requirements so that materials will be managed according to all safety and security provisions.

Spanish regulations also require the specific authorization of all companies supplying radioactive sources. The supply of radioactive sources to organizations or individuals not having specific permits to own or use is forbidden.

The illicit purchase and/or supply of radioactive materials is subjected to enforcement actions from the regulatory authorities.

The long term storage of radioactive materials is not allowed. In the event of regulatory inspectors finding situations where disused sources are being stored, the licensees are required to send them back to the supplier or to arrange for the national company for radioactive waste management (ENRESA) to collect them for disposal.

To avoid situations of deficient safety and/or security during the use of radioactive sources, control by the regulatory body is carried out through periodic reporting of activities and inspections. Organizations licensed to own/use radioactive materials are required by regulations to send a yearly report to the regulatory authorities, including information on the inventory of radioactive sources at their facilities and any other circumstances related to compliance with licence specifications.

Companies authorized to supply radioactive materials are required to send a quarterly report to the regulatory authorities with detailed information about radioactive material deliveries, including all data related to the nature and activities of the radioactive material and the identification of the purchaser.

Yearly regulatory control inspections are performed at the premises of all licensed owners of radioactive sources to verify that no changes have taken place in the inventories of radioactive materials owned and that all safety and security provisions required when the permit was issued are still in force. Situations, such as the use of non-authorized sources or lack of control/radiation safety, are identified in these inspections and required to be corrected by licensee.

Security provisions to preclude access of non-authorized personnel to radioactive sources by design features on equipment (housing and shielding) and facilities (shielding, enclosures, administrative procedures, and surveillance by TV systems in some cases) are also verified during regulatory control inspections.

In relation to maintenance, the periodic technical review of equipment/sources is required in permit specifications within specific time intervals. Maintenance operations must be performed by authorized companies. Licensees and suppliers need specific authorizations when they perform maintenance activities potentially affecting the radiological characteristics of the source/equipment. Compliance with requirements related to maintenance is also verified by the regulatory body through inspections and review of yearly reports.

Practices using mobile sources or equipment represent situations where special precautions for the control of radioactive sources should be taken. Radiography, soil density and moisture gauges and well logging probes are examples of these practices — using, in many cases, high activity sealed sources. Special procedures, both for normal operations and for emergency situations, are required at the licensing stage. In addition, there must be compliance with regulations for the transportation of radioactive substances. Licensed personnel are required by permit specifications to permanently monitor and control sources or equipment when out of their storage enclosures; every movement of sources must be recorded in a devoted diary signed by the radiation protection supervisor. Records should be kept available for regulatory inspection. In addition to periodic regulatory inspections, special inspections devoted to field operations using mobile sources are carried out.

The likelihood of loss of control of sources is especially high when events (incidents or accidents) take place during operations with radioactive sources. Licensees are required at the licensing stage to develop and submit an Emergency Plan for regulatory review, including procedures to be followed for all anticipated events. Licensed persons must receive training on actions needed in emergency situations; periodic refreshing training is required by the operation permit. The availability and readiness of emergency provisions, as well as personnel training activities, are checked during periodic regulatory inspections.

A specific regulation has been issued in Spain on the notification of events to authorities. Any event related to loss of control of high activity sources is required to be notified within one hour of its discovery. The Spanish regulatory body has an emergency organisation to support the other authorities and licensees in emergency situations. Emergency activities in these cases are mainly oriented towards avoiding members of the public becoming exposed to radiation and to the rapid recovery of the source.

The availability of qualified personnel during the time that sources are being used is a key element for maintaining proper conditions for the safety and security of radioactive sources. In Spain, every person in charge of managing or using radioactive sources must have a certificate issued by the regulatory body to show that he/she has received adequate radiation protection training. Use of radioactive sources is allowed only when a minimum number of licensed persons, specified in the permit, are present. Certificates are specific for different uses of radioactive sources; training programmes to obtain each one of them are organized by the regulatory body. Compliance with the requirements related to personal training is verified by inspection and review of yearly reports.

The lack of personnel training (and the corresponding increased risk of losing source control) often occurs when the licensee's company is in some form of crisis. These situations are seldom notified to the regulatory authorities but are often recognized by means of periodic inspections. When a company crisis is detected, the objective should be to ensure a safe destination for the sources at company premises. The first steps are always directed towards forcing the licensee to arrange for the safe management of the sources, but when this is not possible, the regulations allow the authorities to confiscate the sources and take on the task of their safe management.

Another situation of increased risk of loss of control of sources occurs when a source is no longer used or intended to be used for the practice for which authorization was granted. As mentioned earlier, long term storage of sources is not allowed. When such situations are detected, the regulatory body requires the licensee to return the source to the supplier or to manage it as radioactive waste.

According to Spanish regulations, during the licensing procedure for every source, the licensee is required to submit information to the authorities about the financial provisions made by his/her company for decommissioning and to have a signed agreement with the source supplier to return radioactive sources at the end of their use. The decommissioning permit is only granted once it has been verified that the safe management of all radioactive materials included in the authorisation has been completed; compliance with all terms and specifications in the authorisation is required as of that time.

5. RECENT SAFETY AND SECURITY REQUIREMENTS

The approach for the safety and security of radioactive sources described above was implemented in Spain to elaborate principles included in regulations first issued in 1972 and updated in 1999. In 2006, a new regulation (Regulation 229/2006) to address the requirements included in the IAEA Code of Conduct [3] and the European Directive on HASS [4] introduces further requirements for safety and security.

The new regulation recognizes need for sources to be subject to strict control and introduces the requirement to perform a follow up (tracking) of every single high activity source by serial number from the time they are manufactured to the time they are placed in an authorized facility for their long-term storage or disposal. This produces new requirements for licensed source holders, source manufacturers and regulatory authorities.

Source holders are required to send an inventory sheet to authorities every time: they purchase a new source, the source is transferred to another holder or the situation indicated on the previous inventory sheet has changed. They are also required to carry out and record monthly verifications of the source inventory, location and condition. A financial security should be held by source holder to assure the management of disused sources.

Manufacturers are required to assure that each source is identified by a unique number engraved or stamped on the source, where practicable, and provide a photograph of each manufactured source design type and of the typical source container

Regulatory authorities are required to create and maintain a national inventory of high activity sealed sources and source holders as well as systems for source tracking and mechanisms for sources import, export and transfer control.

In relation to the security of radioactive sources, Regulation 229/2006 includes a general requirement for source holders to define measures to anticipate, detect and avoid any situation with an enhanced likelihood of sources becoming out of control.

To achieve these goals, security measures are required to be taken at the facilities where sources are used and/or stored. The regulatory body is responsible for assessment and inspection to verify that such measures are effectively implemented during the licensing procedure and during the operational life of the sources.

According to international standards, security measures should be implemented for sources of category 1 and 2 as defined in the IAEA Safety Guide on Categorization of Radioactive Sources [5]. Provisions to be considered to avoid the access of non-authorized personnel to radioactive sources include devices as barriers, fasteners, alarms etc as well as administrative procedures, such as, key controls and periodic inventories.

The detailed approach for source security to be followed in Spain is still under development. The CSN is responsible for providing the security criteria to be applied and to identify and/or issue technical standards and regulations to be implemented.

Before Regulation 229/2006 was issued, some provisions were in force in Spain related to the management of non-authorized radioactive materials:

— Every person who finds such materials should apply for an authorization for their safe disposal as radioactive waste provided any other alternative for management is not available. Disposal costs should be paid by the person who discovered the materials. A special regime of ‘free cost confiscation’ by authorities applies for ^{226}Ra needles used for medical therapy; this was introduced before the regulatory system was implemented in Spain;
— A protocol was established for authorities, metal scrap recovery companies and the national agency for radioactive waste management (ENRESA) to cooperate on the surveillance of radioactive materials in metal scrap as well as on the management of materials found.

The new regulation reinforces the approach established by the protocol and encourages its application at any other facilities with similar characteristics where there is the likelihood for orphan sources to be found.

For existing orphan sources, practices being implemented before the regulatory system entered into force or from outside that system, Regulation 229/2006 requires authorities to launch campaigns to recover them. The authority in charge is in this case is the Ministry of Industry, Tourism and Trade (MITYC).

To comply with this requirement, MITYC launched a recovery campaign during the years 2007 and 2008 which was later extended to 2009. It has been carried out following guidance issued by the IAEA [6]. It includes the gathering of historical information and analysis, as well as ‘in the field’ searching. Search planning is continuously updated taking into account feedback from previous activities, new information and search results.

By the end of 2008, 122 orphan sources had been recovered with activities ranging from 1 kBq to 76.2 GBq. Most of the sources were of ^{137}Cs, ^{60}Co and ^{241}Am and came from mainly industrial and research activities.

6. NORM FROM OIL AND GAS EXPLORATION

Naturally occurring radioactive materials (NORM) are present in components of both petroleum and natural gas production facilities and are associated with the presence of crude oil, formation/produced water and natural gas. NORM occurring in oil installations mainly contain ^{226}Ra and ^{228}Ra, generally in equilibrium with their decay products. ^{228}Th is sometimes detected in aged sludge and scale as a product of the decay of ^{226}Ra.

The concentrations of these long lived isotopes of radium in formation water show large variations depending mainly on geological characteristics, and operating conditions. Activity concentrations range from below detection limits up to several hundred Bq.l^{-1} Phosphatic rock reservoirs show the highest concentrations of radium isotopes.

Under high temperature and pressure conditions in an oil reservoir, trace concentrations of barium, strontium, calcium and radium are present in soluble forms in the formation water. The water also contains sulphate and carbonate ions. Changes in pressure, temperature, flow rate, water acidity etc and the mixing of incompatible waters, produce the precipitation of ^{226}Ra and ^{228}Ra isotopes jointly with other cations as scales and sludges. The most common scales consist of radium sulphate and carbonate together with barium sulphate and calcium carbonate. Since radium is concentrated within a small amount of solid scale, the radium concentration in scale exceeds the radium concentration in water by several orders of magnitude. Scales build up on the inside surfaces of pipes and other production equipment

As uranium and thorium are substantially less soluble in the formation water than radium, NORM scales contain practically no uranium or thorium isotopes. It can be concluded that NORM in petroleum production facilities mainly contain ^{226}Ra and ^{228}Ra and their short lived decay products.

The short lived progeny of ^{226}Ra, in particular ^{214}Bi and ^{214}Pb, emit gamma radiation capable of penetrating the walls of the components and can be detected.

Since the implementation of the Scrap Protocol in Spain, about 500 notifications have been made concerning NORM (50% of notifications).

7. CONCLUSIONS

Radioactive materials are widely used in many aspects of medicine, industry, agriculture, education and research. The potential exists for these materials to be lost from control if they are not properly managed. Of special concern are those situations related to sealed radioactive sources due to the fact that once the sources are lost from control they have a significant likelihood of ending up as part of metal scrap.

In Spain, the regulatory system for the safety and security of radioactive sources has been recently updated to take into account the latest international recommendations. The system includes sufficient provisions for the control of radioactive materials — with special emphasis on of high activity sealed radioactive sources. The main objective of these provisions is to avoid any situation where sources can be lost from control and become orphan; special attention is paid to source transfers, long term storage and end of life disposal.

Oversight by the regulatory body, together with cooperation between all related authorities, is considered to be necessary to maintain a robust source control system and to safely manage anticipated and/or unexpected events that may arise. Cooperation with companies and organizations devoted to activities in which orphan sources can be encountered is a key element in avoiding potential radiological problems.

Once an adequate system for the control of currently used radioactive sources is in place, the problem of orphan sources from past practices must be addressed. An effective way to do this is to carry out periodic campaigns of search and recovery. Guidance has been developed by the international organizations on how to perform such campaigns.

Although the melt down of scrap from oil and gas industries contaminated with NORM is associated with a low level of radiological hazard, the entry of these materials into scrap factories creates serious disruptions due to the fact that they trigger alarms in the surveillance systems.

International cooperation to implement similar approaches in all countries for source control and orphan source recovery is essential to avoid orphan source transfers between countries. As the metal scrap trade has been identified as one important way for orphan radioactive materials to be transferred, specific surveillance systems for scrap shipments should be implemented everywhere.

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APPLICATION OF THE UNECE RECOMMENDATIONS ON MONITORING AND RESPONSE PROCEDURES FOR RADIOACTIVE SCRAP METAL: FROM THEORY TO PRACTICE

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Abstract

The work of the United Nations Economic Commission for Europe (UNECE) in addressing the issue of radioactive material appearing inadvertently in scrap metal is summarized. After hosting several meetings of national and international representatives of the scrap metal industry and radiation protection experts, the UNECE issued recommendations in 2006 on Monitoring and Response Procedures for Radioactive Scrap Metal. Since then, the UNECE has been exploring, with its Member States, the extent to which the Recommendations have been utilized — by means of a questionnaire. In this paper the results of the questionnaire are presented and, on the basis of the results of the questionnaire, conclusions are drawn and recommendations made for international action in this field for the future.

1. INTRODUCTION

Incidents of radioactive contamination in scrap metal are on the increase. In the USA alone, over 5000 incidents involving radioactive scrap metal were recorded in 2004. A basic reason for the rise in contaminated metal is simply the global increase in the recycling of metal. In 2004, the worldwide consumption of scrap metal was 440 million tonnes, out of which 42% was traded internationally [1]. The demand for recycled metal is related to its relative cost, the associated reduction in greenhouse gas emissions and the lessening of the need for further ore mining (with its associated negative environmental impacts). As this trend increases, so does the risk of contamination with radioactive materials - as metals from diverse origins are gathered as scrap and re-processed.

In addition, more sophisticated detection equipment coupled with a growing awareness about the problem, has led to more alarms being sounded. While most of the alarm events only signal small amounts of naturally occurring radioactive material (NORM), each alarm event has to be taken seriously. The cleanup efforts faced by companies when a serious contamination incident happens can reach tens of millions of dollars and risk putting companies out of business. Thus, the health, environmental and economic impacts of radioactive scrap metal are of growing concern.

2. UNECE'S WORK TO DATE

In 2001, the United Nations Economic Commission for Europe (UNECE) began tackling the issue of radioactive scrap metal. The UNECE defines radioactive scrap metal as comprising 'radioactively contaminated scrap metal, activated scrap metal and scrap metal with radioactive source(s) or substances contained within it. The term 'radioactive scrap metal' may include radioactive substances that are within regulatory control and radioactive substances that are outside regulatory control' [2]. It should be noted that while the UNECE's constituency is essentially within Europe and North America, this particular work has had a global scope.

In 2002, in cooperation with the IAEA and the European Commission (EC), the UNECE published a report on the Improvement of the Management of Radiation Protection Aspects in the Recycling of Metal Scrap [3]. The report recommended measures to avoid the introduction of radiation sources into the metal recycling stream. As a result of that report, it was decided to set up a UNECE Expert Group, which met for the first time in 2004 and again in 2006. The Group sought to encourage exchanges of experiences and practices, to promote the harmonization of best practices in preventing incidents from radioactive scrap metal and to support the prompt and effective resolution of any such incidents.

At the 2004 meeting, the UNECE Expert Group recommended that work be undertaken in the following three areas:

— Development of a 'protocol' or 'recommendations' providing for a consistent and internationally harmonized approach to monitoring and response procedures;
— Improved information exchange via an international web portal;
— International training and capacity building programmes on the topic of monitoring and responding to incidents involving radioactive scrap metal.

In order to obtain a better understanding of the current international situation concerning radioactive scrap metal, a detailed questionnaire covering the areas of concern was sent to over 60 countries in 2004 and 2006. An analysis of the responses from 55 countries helped support the development of the UNECE Expert Group's Recommendations on Monitoring Radioactive Scrap Metal which were agreed to at the 2006 meeting [2].

The UNECE Recommendations [2] are intended to complement existing programmes, provide concrete guidance based, to the extent possible, on existing national, regional and international instruments and standards, and on national experience. They aim to support States in developing their own systems of monitoring and response while encouraging further cooperation, coordination and harmonization at the international level. The document is also intended to facilitate international trade in, and the use of, scrap metal without compromising safety. Both radioactive substances that are subject to regulatory control and radioactive substances that are outside such control are covered by the Recommendations.

Further to the development of the Recommendations, and to address the need to build capacity identified by the Expert Group, in 2006, the UNECE, together with the United Nations Institute for Training and Research (UNITAR), undertook a survey of existing capacity building materials in 20 countries, including a number of organizations and industry, to identify the main focal areas and gaps in capacity building and training associated with the issue of radioactive material in scrap metal. Based on this survey, a training and capacity building strategy was developed intended to support States in defining their training gaps and addressing them [4].

All relevant activities can be found on a dedicated section of the main UNECE website (see:http://www.unece.org/trans/radiation/radiation.html). It contains the Recommendations, a series of tools, national best practices provided by different countries, publications and some training and capacity building materials as well as relevant links.

3. ANALYSIS OF USE OF THE UNECE RECOMMENDATIONS

The UNECE's project on monitoring radioactive scrap metal officially terminated in 2007. Nonetheless, in an effort to determine the use that has been made of the Recommendations and the possible need to update them, the UNECE circulated a questionnaire in late 2008 to gauge, two years on, how effective the Recommendations had been and whether they needed to be amended. The questionnaire was circulated to 61 governments, seven intergovernmental organizations, one non-governmental organization and seven companies active in the recycling of metal.

The questions were on the following topics:

A. Presentation of the Recommendations;
B. Scope of the Recommendations;
C. Content of the Recommendations;

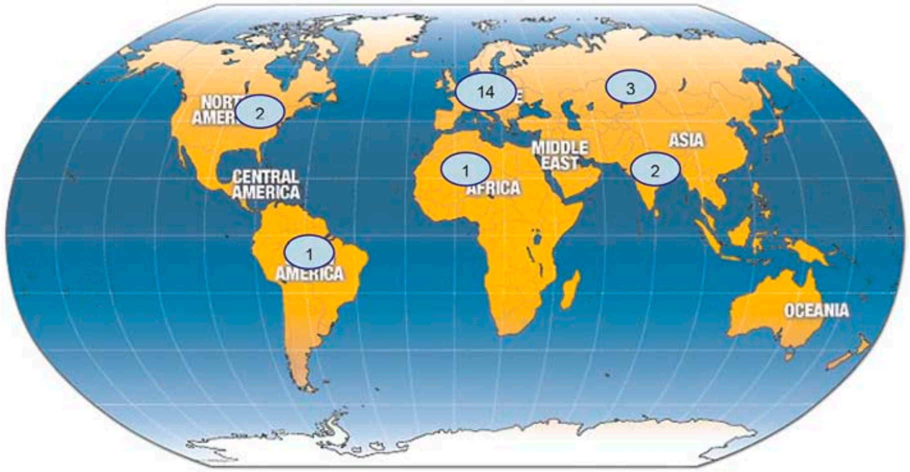

FIG. 1. Respondent universe (number of respondents per region).

D. Use and implementation of the Recommendations;
E. Impact of the Recommendations;
F. Next steps.

An analysis was undertaken [5] based on 23 responses received by the end of 2008 covering the majority of the globe as shown in the map below.

A summary of the analysis is given below, sub-divided as in the questionnaire.

A. Presentation of the UNECE recommendations

While some suggestions were made for possible improvements, respondents generally considered the presentation of the recommendations to be very good.

B. Scope of the UNECE Recommendations

About half of the respondents (48%) felt that the recommendations covered all the necessary ground. The remainder suggested including more information on data and reporting, checks at different locations, e.g. at borders, further details on training and awareness raising, more details on treatment and disposal and further details on liability and responsibility. The majority of respondents (61%) felt that the recommendations addressed all the right actors, with the remainder suggesting the inclusion of the police, the waste treatment/management sector and manufacturers/importers of goods containing metal.

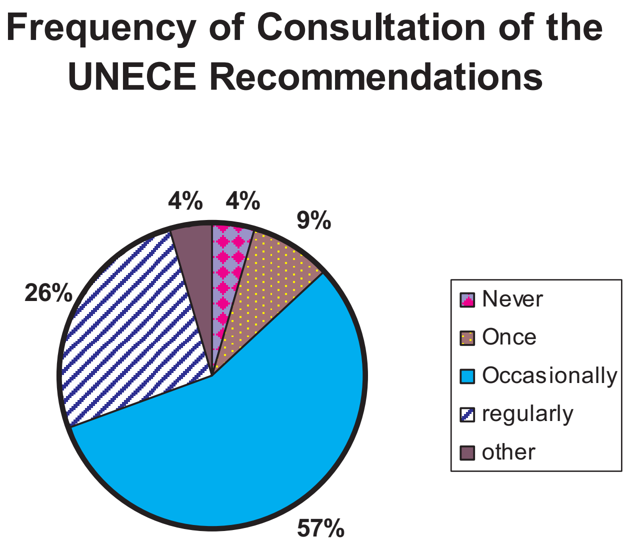

FIG. 2. Response to question on use made of the recommendations.

C. Content of the UNECE Recommendations

Respondents to the questionnaire provided detailed responses on improvements to different sections of the Recommendations (see detailed analysis report [5]).

D. Use and implementation of the UNECE Recommendations

The pie chart in Fig. 2 shows the extent to which the Recommendations have been used, with 83% consulting the Recommendations either occasionally or regularly.

Furthermore, respondents were asked with how many colleagues they had shared the recommendations, in order to determine the reach of the document. Based on the responses it can be estimated that, in addition to the core group of recipients of the UNECE recommendations, an additional group of between 490 and upwards of 1000 received the document.

E. Impact of the UNECE recommendations

In just two years, the recommendations have served as a trigger for a number of changes in different countries. These include new legislation, procedures or even new institutions in one case.

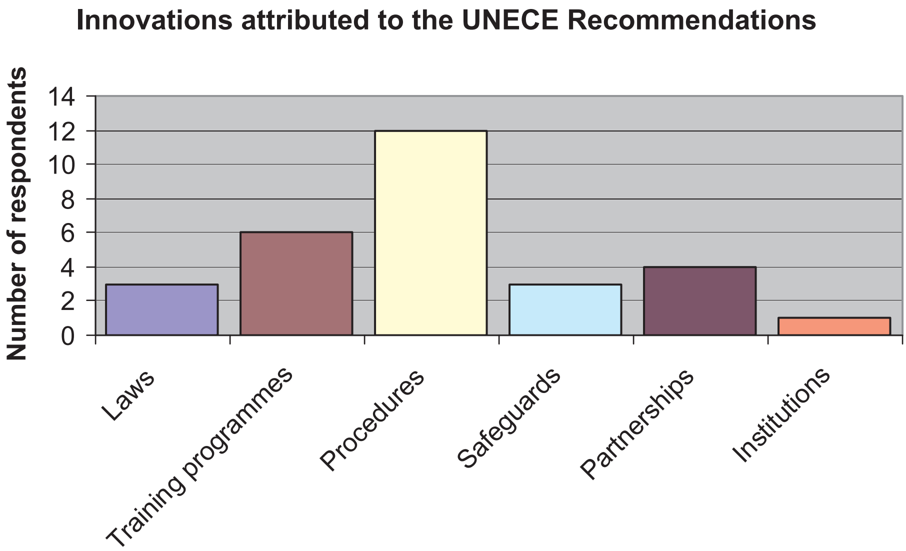

FIG. 3. Identified innovations attributed to the recommendations.

Figure 3 identifies innovations that have been attributed to the UNECE Recommendations.

Respondents were asked to identify lessons learnt from the recommendations. They highlighted notably the global importance of the issue and the urgent need for international collaboration, as well as the importance of allocating clear responsibilities.

F. Next steps

In terms of future work related to the UNECE recommendations, five countries (Belarus, Brazil, Morocco, Romania and the Russian Federation) felt that they should be more detailed, eleven respondents felt that they should be more widely distributed (Belarus, Canada, India, Ireland, Latvia, Luxemburg, Morocco, Romania, Serbia, UK and the USA), and seven countries (Bulgaria, Czech Republic, Ireland, Romania, the Russian Federation, Tajikistan and Vietnam) felt that they should become legally binding.

4. CONCLUSIONS AND RECOMMENDATIONS

Two broad conclusions can be extracted from the detailed analysis:

(1) The UNECE recommendations have played an important role to date and will continue to be a useful tool.
(2) There is a role for a continued international programme or 'centre of expertise' on radioactive scrap metal that can bridge both the public and private sectors.

The analysis above demonstrates that the UNECE recommendations have clearly been used by a large number of practitioners. In turn, these same practitioners have provided significant feedback on ways in which the UNECE recommendations can be improved to make them more useful.

A. Updating and improving the UNECE recommendations

It is proposed to update the UNECE recommendations taking into account feedback received from practitioners, as well as developments in the last couple of years. Taking each section of the recommendations in turn, the following information could be added:

Part I: General provisions

The paragraphs on national actions and actions by industry need updating. Information on best practices and photographs could be inserted. More could be added on typical concentrations of NORM and more information on the most dangerous spent sources. The issue of transboundary shipment of such materials could be elaborated. More information could be included on the movement and storage of radioactive material. Options for making decommissioning less costly and more effective may need to be considered. Collaboration between government and the private sector is still an issue and more guidance and options could be provided on how to improve this collaboration. More guidance could be provided on responsibilities — including liability and inclusion of insurance schemes.

Part II: Fields of action

Prevention

Options for creating incentive programmes to encourage the identification and reporting of radioactive scrap metal could be elaborated.

Detection

More information on detectors and their sensitivities, calibration, positioning etc. could be included. Further details could be added on border controls. The inclusion of more examples as well as photographs could be considered.

Response

More examples of successful response procedures and clearer direction on international reporting and harmonization of response procedures could be provided. More information could be given on the disposal of detected material.

Part III: Additional provisions

More guidance could be included on training of personnel and on information exchange (across countries and within countries between government and the private sector, for instance).

Annexes

Further concrete examples from different countries and companies could be included.

The format of the recommendations could be reconsidered, for instance, presenting them more explicitly by target audience and also including a searchable web version with hyperlinks. Other ‘actors’ should be included within the recommendations, such as the police, the waste sector more broadly and manufacturers/importers of consumer goods.

B. International private-public partnership (centre of expertise)

Expertise exists within the IAEA on addressing regulatory issues with respect to radioactive waste and the international transport of such waste. Similarly, the EC has expertise, particularly in legislative and training aspects.

The scrap metal and metal processing industry has significant experience and know-how when it comes to monitoring scrap metal for radioactivity and in prevention, detection and response procedures. Different industry associations, such as the Bureau of International Recycling (BIR), also play an important role in disseminating information, raising awareness and providing support to address the issue.

However, outside regulatory provisions, there are no international mechanisms that would allow for a comprehensive approach, embracing all parties in the metal recycling chain and concerned Governmental authorities, addressing not only regulatory, but also economic and financial aspects of the problem. Given the global nature of the industry and the numerous parties involved in the metal recycling chain, individual actors are not able to impose or encourage harmonized or standard solutions that would be of benefit for the whole recycling industry as well as to the economy and society at large. In addition, it is often not easy to bridge the private and public sectors, both of which have important roles to play in managing this issue.

An international private-public partnership or centre of expertise could be an avenue for integrating the key industry and governmental actors across sectors, allowing for an exchange of information and best practice and for tackling the problem of radioactive scrap metal jointly and in a coordinated manner. Such a partnership could complement existing activities, such as those of the IAEA and the private sector.

The overall objective of such a public-private partnership would be:

— Promotion of energy efficient recycling of metal resources by effectively managing, in a harmonized manner, the risk of radioactive scrap metal and minimizing its impact on business, health and the environment.

Partners would need to adhere to this overarching objective. Each partner entity would, however, contribute in its own way to this objective and would inform others on a regular basis.

Such a public-private partnership could have three (3) main modules:

Module 1 Implementation

Further development, fine tuning and use of the UNECE recommendations, gathering lessons learnt and experiences from applying the recommendations, with a view to reaching comprehensive voluntary international standards in prevention, detection and response procedures, including insurance schemes.

Module 2 Capacity building

Organization of: training workshops, mechanisms for the exchange of experiences, expertise and know-how, exchange programmes and workshops on relevant emerging topics.

Module 3 Trade and transport facilitation

Preparation of guidelines on procedures and mechanisms to facilitate international trade and transport in scrap metal (that is potentially radioactive) and exchange of experiences and promotion of best practices, including best practices for customs authorities and the transport industry.

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NATIONAL POLICIES AND STRATEGIES

(Session 2)

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SUMMARY OF SESSION 2

NATIONAL POLICIES AND STRATEGIES

In this session, some of the national policies and strategies being used to address the control of inadvertent radioactive material in scrap metal were presented. In addition to the papers presented orally in this session, there were contributions describing the situation in many countries of the world in the form of posters displayed during the conference. The many posters reporting national measures being used to control radioactive material in metal scrap at the conference served to indicate the global extent of the problem.

As a result of a serious incident which occurred in Spain involving the melting of an orphan radioactive source, a national system to address the issue was instituted. This system, known as the Spanish Protocol, involves all relevant national stakeholders, that is, the scrap metal industry, the steel industry, the national nuclear regulator and the national radioactive waste management organization in a voluntary collaborative scheme aimed at preventing the occurrence of radioactive materials in scrap metal through administrative controls and detection methods. The essential feature of the scheme is that it provides national support for the scrap and steel industry in return for openness and transparency. In the event of radioactive material being found in scrap metal the system provides professional help and resources to manage the situation. It is relevant to note that in Spain a facility exists for the disposal of low and intermediate level waste; this feature allows for the safe disposal of the radioactive material found in scrap metal or from the cleanup of contaminated premises. The Spanish Protocol has provided a model for the creation of other national and international schemes.

Experience with radioactive material appearing in scrap metal shipments and arrangements for its management were described for several middle European countries (Bulgaria, Ukraine, Slovenia, Georgia). Most of the detected radioactive materials are NORM radionuclides (^{226}Ra, ^{232}Th etc.) (70%) and typical orphan source radionuclides (^{60}Co, ^{137}Cs) (30%). The systems in these countries are usually based on the principles of prevention, detection and response and follow the UNECE guidelines. In all countries the control and monitoring of shipments of scrap metal from beyond national borders is a serious issue and the management of identified contaminated loads is a regular problem. In Bulgaria, the State takes the ultimate responsibility for any radioactive material found in scrap metal while in Ukraine a special fund exists for the management of radioactive waste.

In two contrasting presentations, the management of very low activity level material being released from the nuclear industry was discussed. An industry scheme in the UK for the clearance and exemption of materials from nuclear sites was described. A national working group has developed and agreed with all partners a consistent methodology for use across the UK nuclear industry. In France, clearance is not allowed because of ethical and public concerns and instead a zoning system within the facility being decommissioned is used to determine which materials may be released.

In the panel session which followed the oral presentations the following topics were discussed:

The presentations described well developed national strategies for managing the problem of radioactive material in metal scrap. However, it is apparent that these are purely national arrangements; there is no international strategy for this purpose. Countries manage the transboundary problems using their own mechanisms and resources but there appears to be little coordination between them. For example, there is no requirement to report to other potentially concerned countries that a load has been rejected at a border; there is no requirement for the provision of certificates confirming that scrap metal loads both entering and leaving the country have been monitored for radiation; there is no requirement to monitor loads which are in transit through the country; finally there is no agreement on acceptable levels of radionuclides in metal scrap. Arrangements for the return of detected radioactive material or loads of scrap metal containing radioactive material to the supplier are made on an ‘ad hoc’ basis with no internationally agreed procedure.

Based on these concerns, the discussions in this session focussed on the need for an international approach to the problem. It was concluded that there is a need for some form of binding international agreement that improves arrangements for the transport of scrap metal by preventing the occurrence of loads containing radioactive material, increases the likelihood of their detection and facilitates response mechanisms in the event of material being discovered. The agreement should enhance cooperation and collaboration between countries in this context. It should take account of the needs and requirements of all relevant stakeholders including scrap metal companies, the steel industry, national regulators, border authorities etc. The existing UNECE recommendations could be used as a starting point for this agreement. The actual mechanism to be used to achieve these goals should be decided upon by the relevant international organizations. In this context, it was noted that international organizations concerned with international trade such as the World Trade Organization should be involved.

THE SPANISH PROTOCOL FOR COLLABORATION ON THE RADIOLOGICAL SURVEILLANCE OF METALLIC MATERIALS

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Abstract

In recent years the presence of radioactive material in scrap metal has been detected relatively often. This can cause the contamination of people or of the environment, as well as of the industrial facilities and of the product. The Spanish iron and steel industry is one of the most important industrial sectors in the country, and depends to a large extent on the importation of a significant proportion of the scrap used as raw material. Experience has shown that countries that import large quantities of scrap for their industries are more exposed to the existence of orphan radioactive sources and therefore, they have to adopt measures to reduce the risks arising from their presence. In 1999, the Spanish authorities, along with the business associations involved in the metal recovery and smelting industry, and the radioactive waste management agency, established a national system for the radiological surveillance and control of scrap metal and the products resulting from its processing. Since then, the most relevant trade unions and others in the industrial sector have also joined the system. It is based on the existence of a legal framework and on a set of voluntary commitments taken on by the involved parties. It is known as the Protocol for Collaboration for the Radiological Surveillance of Metallic Materials and is implemented by the installation of specific radiological surveillance equipment, the development of radiological training and information plans for the staff involved in the metal recovery and smelting sectors, the definition of a fully operational system to safely manage the materials detected, and a general improvement of the national radiological emergency system.

1. BACKGROUND TO THE SITUATION IN SPAIN

The incident that took place in May 1998 in a stainless steel factory located in the south of Spain, in which a caesium-137 radioactive source of foreign origin was inadvertently smelted with scrap metal, revealed the need for measures to be adopted to prevent, as far as possible, any repetition of the event and, if it were to re-occur, to limit its consequences.

This event gave rise to a public concern that showed itself in parliamentary initiatives from the most important political parties, parliamentary questions addressed to the Government, and motions addressed to the Administration by some town councils.

The Nuclear Safety Council (CSN), the Spanish body responsible for nuclear safety and radiation protection, and also some Spanish companies were already aware of the risk. The CSN had established preliminary contacts with steel facilities and carried out a campaign to provide information on the radiological risk associated with metal scrap, in addition, some steel facilities had installed monitoring devices.

2. MEASURES ADOPTED FOR THE RADIOLOGICAL SURVEILLANCE OF METAL SCRAP

The metal scrap market is an international market and, for example, the Spanish steel industry imports about the half of the scrap that it consumes, which represents of the order of 7 million tons of metal scrap per year. Therefore, the effectiveness of the measures of surveillance and control to be established would be substantially reinforced if these measures were adopted internationally.

Having that in mind, the Spanish Administration initiated a set of actions, both at international and national levels.

2.1. International situation with reference to prevention of the occurrence of radioactive material in metal scrap

In 1998, no international organization with competence in the radiological protection field and, more concretely, the IAEA, the European Commission (EC) and the Nuclear Energy Agency of the OECD (NEA/OECD), had established procedures or directives applicable to the surveillance and radiological control of metal scrap.

The EC, through the Article 31Group of Experts of the EURATOM Treaty, had issued recommendations on levels of radionuclides that were considered as acceptable for the recycling of scrap from nuclear facilities. The IAEA had issued provisional recommendations for the management of solid materials that contain low concentrations of radioactive materials, and in collaboration with other international organizations it was preparing a Safety Guide for preventing the illegal international trafficking of radioactive materials.

Radiological scrap monitoring systems had been installed in steelworks, in some metal recovering centres and on some borders of OECD countries. In almost all cases, the installations were voluntary and based on recommendations of the industry or of national or regional organizations responsible for radiological protection.

In summary, it could be said that the situation was far from homogeneous or harmonious and that there was no systematic practice for the regulation of radiological scrap monitoring on an international or national scale, with the exception of Italy where there was some regulation but it was not generally applied.

In view of this situation, the Spanish Authorities, considering that this issue was also an object of concern for other Members States and for the European Commission, in September 1998, asked the Members of the Commission responsible for environmental and industrial matters to promote inside the European Union the necessary initiatives for the control of scrap contaminated with radioactive material.

In her response, the Commissioner responsible for environmental matters informed the Spanish Authorities that the European Commission had initiated a process of reflection on possible actions in this area, having in mind that it was a very complex problem.

Later, the European Commission started the process of elaboration of a Directive on safety of radiation sources, which gave rise to the Council Directive 2003/122/EURATOM of 22 December 2003, on the control of high activity sealed radioactive sources and orphan sources, and a Group of Experts was set up to study the possibility of developing a specific regulation on radiological controls in ports and at borders with third countries.

Other international organizations, among them, the IAEA, started a series of initiatives aimed at detecting and avoiding the international illicit trafficking of radioactive material. The IAEA initiated an Action Plan on the safety of radioactive sources, which included the elaboration of a Code of Conduct on the Safety and Security of Radioactive Sources that was supplemented later by the Guidance on the Import and Export of Radioactive Sources. These actions were strongly promoted as a result of the increase of worldwide concern about the need to avoid the malicious use of radioactive sources after the terrorist attacks of September 11, 2001.

2.2. Actions at the national level

When the incident at a factory of the south of Spain occurred in1998, the Spanish regulations neither considered specifically the risks stemming from the presence of radioactive materials in scrap, nor called for its radiological surveillance.

At this time, the Law regulating the CSN was being reviewed by parliament. It included: updating of the functions of the CSN, new tariffs and prices for services rendered by the CSN, and the assignment of new areas of competence to the CSN in relation to the radiological protection of the environment throughout the Spanish territory, such as:

- *"inspect, assess, control, report and propose to the competent authority the adoption of all preventive and corrective measures required in exceptional emergency situations… when they originate in facilities, equipment, enterprises or activities not subject to the system of permits provided in nuclear legislation."*
- *"control and monitor the radiological quality of the environment throughout the nation… and collaborate with the competent authorities in matters of environmental radiological monitoring outside the zones of influence of nuclear or radioactive facilities."*

The Law also established that the management of radioactive waste generated in exceptional circumstances may be charged to the fund set up to manage radioactive waste, when the cost of such management cannot be applied in accordance with the regulations and when it is so determined by the Ministry of Industry, Tourism and Trade (MITYC).

2.3. The Protocol for Collaboration on the Radiological Surveillance of Metallic Materials

In July 1998, the MITYC and the CSN set up a Working Group to consider the possible measures to adopt at the national level. The Working Group included the Spanish radioactive waste management agency (ENRESA) and also the industrial bodies involved in the recycling of metals.

The analyses carried out by this Working Group made evident the complexity of the issue, since it involves not only aspects of radiological protection and the environment but also issues of a technical, industrial, economic and commercial character.

During the Protocol preparation many of the difficulties that arose resulted from the conceptual divergences between the two worlds of radiological protection and commerce.

The first one concerned industrial sectors that:

- Had specific working rules but were not used to having to take account of radiological protection regulations;
- As a principle issue, did not wish to be associated with the radiological or nuclear sector, as a result of the distrust that radioactivity provokes in many non-nuclear sectors;
- Argued that they were 'victims' of a system that had failed to control its materials and that they were carrying out 'social work' in recovering orphan radioactive sources.

The second one concerned the national administrative entities responsible for nuclear and radioactive matters, that:

— Were used to work with activities subject to rigorous and specific regulations;
— Maintained that the risk to the concerned industrial activities depends, to a certain extent, on the 'quality' of the raw material that they used.

In this Working Group, two options were considered for adopting the necessary measures to approach this issue: the possibility of elaborating a regulation, or the establishment of mechanisms of collaboration on voluntary basis among the Administration and the concerned industrial sectors.

Finally, bearing in mind the above, as well as the non-existence of regulation at international level, it was considered that an effective and realistic approach for carrying out radiological surveillance would be the establishment of a framework of collaboration on a voluntary basis, without excluding the possibility that, there might be the eventual adoption of a regulation at a European Union level that could give to these measures a normative status.

Thus, on November 2, 1999, the Spanish Authorities and the concerned industrial sectors signed a Protocol for Collaboration on the Radiological Surveillance of Metallic Materials, of voluntary character, which established a series of commitments and actions to be carried out by each of the signatories, in order to improve the radiological surveillance of metallic materials and the management of the radioactive materials that are detected as a result of the surveillance, or that could be generated as a consequence of an incident.

Initially, the Protocol was signed by the Ministry of Industry, Tourism and Trade, the Ministry of Public Works, as Department in charge of the Autonomous National Ports Organization, the Nuclear Safety Council, the National Company for Radioactive Waste (ENRESA), the Union of Iron and Steel Companies (UNESID) and the Spanish Federation for Recovery (FER). Later, the most relevant Trade Unions (CC.OO. and UGT) and other entities of industrial sectors, such as the Spanish Federation of Smelters also signed the Protocol.

The Protocol contains a main text with the basic agreements and a technical annex describing the operational actions to be undertaken by the parties, including, to create a register at the MITYC for the implementation of this Protocol, and to promote the inclusion of companies in this register.

It establishes a technical commission to follow up its operation and to learn from experience. The technical commission is composed of representatives of all signing parties and meets periodically. On this basis, a new revision of the technical annex was elaborated and entered formally into operation in January 2005.

To facilitate the development of the tasks assigned to the technical commission for the follow-up of the Protocol, a Technical Working Group has been set-up. This Group is led by the representatives of CSN, and has terms of reference which have been approved by the Technical Commission.

2.4. Commitments of the parties

— The MITYC undertakes to carry out the following:
  - To issue a generic resolution awarding Authorization for Transfer to ENRESA of the radioactive material detected at the installations, in accordance with the legal provisions in force and subject to a report from the Nuclear Safety Council.
  - To create and keep updated a Register of the Installations of the subscribing companies, informing both the Nuclear Safety Council and the affected companies of the inclusion of each installation on the said Register.
  - To carry out whatever actions are required to resolve situations requiring exceptional measures, due to the presence of radioactive materials in the metallic materials and resulting products. Such actions shall be undertaken, where appropriate, in coordination with other competent public bodies and with the affected companies, subject to a report from the Nuclear Safety Council, which shall be mandatory and binding in areas within the scope of its competence.

— The Ministry of Public Works has to inform the Nuclear Safety Council of any radiological event occurring within the framework of its competence and related to the transport of metallic materials.

— The Nuclear Safety Council (CSN) undertakes to carry out the following:
  - To inform ENRESA and the subscribing companies of the application of the Authorization for Transfer where appropriate.
  - To issue the generic technical instructions and recommendations it considers necessary for the application of this Protocol.
  - To know about the registration of installations on the MITYC Register and, where appropriate, to issue the technical instructions or recommendations it considers necessary to guarantee that the surveillance and control system fulfils the agreements established in the Protocol.
  - To inspect the surveillance and control system established by the subscribing company and to issue to the latter whatever instructions it considers to be appropriate for compliance with the agreements established in the Protocol.

- To advise the competent authorities and subscribing companies in matters relating to safety and radiological protection for compliance with this Protocol. Particularly and on urgent basis, in those cases in which radioactive sources or material, not acceptable for such a destination, has been processed.
- To promote campaigns for training and education on radiological protection among the personnel of companies involved in the metal recovery and smelting sector, in relation to the activities of such companies.

— The National Company for Radioactive Waste, S.A. (ENRESA) undertakes to carry out the following:

- To remove and take custody of the radioactive materials detected in the installations of the subscribing companies and transfer them to its own premises.
- To render technical advisory services to the subscribing companies, particularly and on urgent basis, in those cases in which radioactive sources or material, not acceptable for such a destination, have been processed. In these cases, the technical and administrative actions with reference to the affected installation will be supported, in order to reduce the period of recovery and to optimize the management of the radioactive waste.
- If necessary, to collaborate with the subscribing companies in returning radioactive materials to the dispatching party when the latter is a foreign agent.
- To collaborate in the training plans for the technicians required to act in the event of radioactive materials being detected.
- To collaborate in the campaigns for training and education on radiological protection among the personnel of companies involved in the metal recovery and smelting sector.
- To enter into a contract with the subscribing company for the management of radioactive materials, in accordance with the stipulations established in the Protocol.

— The subscribing company undertakes to carry out the following:

- To undertake the radiological surveillance of metallic materials and resulting products. To this end, it shall:
  - Install, operate and maintain a surveillance and control system. The system will include surveillance of the metallic materials, the industrial processes and the resulting products, according to the type of activity and the technological availabilities.
  - Provide the surveillance and control system with technical personnel specialized in radiological protection, providing the latter with the instrumentation, areas for temporary location and action and

communication procedures required to detect, separate and isolate whatever radioactive materials that might be detected.
  - ○ Provide basic radiological protection and surveillance training for its personnel, suitable for its activities, and inform such personnel of the characteristics of the surveillance and control system.
- In the case of trans-frontier movements, imports or intra-Community trade in metallic materials, the subscribing company:
  - ○ Shall require from the dispatcher a certificate of inspection of the merchandise, issued by a reliable entity, in which it shall be established the radiological surveillance and control system that the dispatched metallic materials have been subjected to and the obtained results.
  - ○ Shall not unload on Spanish territory whatever maritime shipments that are not accompanied by the certificate referred to in the previous point.
- To initiate, by itself or with collaboration from ENRESA, the actions required to return to the foreign dispatcher whatever radioactive materials that might eventually be detected.
- To immediately notify the CSN of the detection of radioactive material in shipments of metallic materials or resulting products, using the form included in the Protocol.
- To adopt whatever measures that might be required to prevent the dispersion of radioactive material.
- To enter into a contract with ENRESA for the management of radioactive materials, in accordance with the stipulations established on the Protocol.
- To transfer radioactive material detected to ENRESA.
- To collaborate in the campaigns for the training and education in radiological protection of the personnel of companies involved in the metal recovery and smelting sector.

2.5. Response to the detection of radioactive materials

The Protocol also establishes the procedures to follow in response to the detection of radioactive material in scrap, in the process or in the resulting products.

— In the event of radioactive material being detected in a shipment of metallic materials arriving at the installation, the subscribing company must:
- Immobilize the shipment within the installation in which it is detected;
- Alert the technical personnel specialized in radiological protection, who shall proceed as follows using adequate radiological protection procedures; inspect the shipment in detail until the part or parts containing the radioactive material is/are identified; evaluate the nature and quantity of radioactivity contained therein; isolate the radioactive

material under safe conditions; and draw up a report describing the actions taken and the results and establishing whether the radioactive material is exempt from nuclear regulation or should be transferred to ENRESA;

- Notify the CSN using the form included in the Protocol, attaching the conclusions of the report drawn up by the personnel specializing in radiological protection;
- Transfer the radioactive material to ENRESA under the terms established in the Authorization for Transfer;
- Keep the radioactive material in custody under safe conditions until it is removed by ENRESA.

— In the event of radioactive material being detected during the process or resulting products, the subscribing company shall carry out the following, for which it shall receive without delay advisory services from the CSN:

- Immediately notify the CSN via the quickest possible channel of such detection, transmitting the available information,
- With advice from the CSN, attempt to ascertain whether the detection is real. To do this, the subscribing company, either through its own personnel or with the support of a UTPR (Radiological Protection Technical Unit) contracted for this purpose,
- If the detection is real, the subscribing company shall proceed as follows, with advice from the CSN:
  - Interrupt all the phases of the process that are understood to be affected, except those whose operation helps to mitigate the consequences, as well as cleaning and decontamination tasks;
  - Immediately suspend the exit from the installation of products that have been in contact with the contaminated source;
  - Provide immediate notification of the situation to any organization that has received products suspected to have been affected by the incident, where applicable;
  - Require the intervention of a UTPR authorized for this purpose, which shall determine the extent of the contamination on the processing chain and immediate surroundings.

— If the detection has been in metallic materials, the CSN shall proceed as follows:

- Instruct the subscribing company to transfer the radioactive material to ENRESA, in application of the Authorization for Transfer;
- Notify ENRESA that the radioactive material will be transferred to it in application of the Authorization for Transfer.

— If the detection has been in the processing chain or resulting products, the CSN shall:

- Notify the MITYC and recommend actions to be taken;
- Advise ENRESA of the existing situation;
- Provide immediate and direct advice to the subscribing company, issuing whatever instructions and recommendations it considers necessary;
- Order whatever measures it considers necessary to be taken by the personnel and technical support organizations of the CSN.

— ENRESA shall proceed as follows:

- Remove the radioactive materials, in application of the Authorization for Transfer;
- Keep the radioactive material removed in safe custody until a decision is taken regarding the method for definitive management to be applied to it, which might be one of the following:
  - return to the supplier if the latter is foreign;
  - transfer to another authorized body;
  - management as radioactive waste;
  - any other legally authorized method.
- Immediately provide the subscribing company with the support required for its activities, when radioactive sources or materials may have been processed.

When radioactive sources or materials may have been processed, the CSN shall propose to the MITYC that it require the subscribing company to draw up an Action Plan for adoption of radiological protection and necessary management measures. The Plan is to be submitted to the CSN and the MITYC and shall be subject to the favourable assessment of the CSN, which shall provide the company with the instructions it considers to be necessary and, where appropriate, inform the company when it may reinstate normal operations.

The actions contemplated in the Plan may not be considered to have been concluded until the CSN reports favourably to the MITYC on the results obtained and the latter communicates it to the company.

When, in the judgment of the CSN, the situation resulting from the contamination by the dispersion of radioactive material at the installation so requires, the MITYC may, without delay and taking into account the preliminary report issued by the CSN, require that whatever exceptional measures it considers appropriate be adopted, in coordination where necessary with other competent public organizations and with the affected companies.

2.6. Assignment of costs

The Protocol establishes that the costs deriving from the management of radioactive materials detected shall be borne by the subscribing company, without prejudice to the possibility of these being applied to the supplier or dispatcher where appropriate. As an exception, the costs derived from the management of radioactive sources detected in metallic materials from the Spanish national territory shall be borne by ENRESA.

2.7. Complementary documentation

The practical application of the Protocol is supported through a set of specific documents:

— Keeping in mind that, in accordance with the Spanish regulation, all transfers of radioactive material must be authorized by the MITYC, with a previous favourable report of the CSN, a 'Generic Authorization for Transfer' has been issued. This authorization establishes the criteria to define the levels of investigation and of exemption, and other additional necessary precautions needed to guarantee the safety of the established system and of the transfer to ENRESA of the radioactive materials.
— The CSN has issued a Safety Guideline on the radiological control in the recovering and recycling scrap activities in which recommendations on the technical characteristics of the system of surveillance and control, the training of technical specialists, the capacities of the UTPR (Radiological Protection Technical Unit), etc. are given.
— ENRESA has signed with the subscribing companies a 'standard contract' in which the contractual conditions for the transfer of the radioactive material that is detected are established.

2.8. Training and dissemination activities

One of the most important aspects of the Protocol is to provide information and training to the workers of the metal industries who may be involved in the detection of radioactive material.

The Protocol provides a platform for the development of a radiological protection training and dissemination programme and of instrumental techniques for the personnel of member facilities. This programme consists of three levels:

— One of a general nature regarding the bases of radiological protection and the risks stemming from the presence of radioactive material in scrap, targeted at managers and other technicians of steelworks and scrap warehouses. It involves the development of basic training courses.
— One of a technical nature regarding instrumental techniques and early actions, targeted at the technicians who must intervene when radioactive

material is detected in a scrap shipment. It involves the development of specialized training courses.

— One of an informative nature, targeted at all personnel in the metal smelting and metal recovery sector, to encourage the prevention of risks caused by the presence of radioactive material in scrap.

The CSN has issued a large format poster with photographic material to be posted in workplaces, for the dual purpose of reminding people of the need to prevent radiological risks and of facilitating the identification of radioactive material. This poster has been supplemented with a triptych and an informative brochure that explains in detail the objective and contents of the Protocol. All these materials are aimed at people who work in steelworks and large scrap warehouses.

2.9. Some aspects of the putting the Protocol into practice

From an instrumental point of view, the Protocol is put into practice by installing radiation detection systems in metal smelting plants and in reclamation centres where scrap is processed (compacted, fragmented, cut, etc.).

The monitoring and control systems of member companies may use different kinds of instruments depending on the dimensions and characteristics of the process developed in them:

— Radiation detection portals located at plant entrance end exits — to detect radiation in the shipments of metallic materials;

— Portable systems of detection — for the detailed inspection of the shipments in which radiation has been detected or for its use in equipment recovery installations of small size;

— Systems for spectrometry analysis of samples taken during the process to assure the quality of resulting products.

In addition, beacon type radiation detection systems may be installed in some installations, in areas of special interest.

With reference to the requirement of a radiological control certificate for imported scrap, the experience gained on implementing the Protocol has shown that in certain circumstances, e.g. when shipments are from undeveloped countries, it is very hard to obtain a radiological control certificate issued by a recognized entity.

Faced with this situation, the technical commission for the follow-up of the Protocol has revisited this Protocol agreement and prepared a certificate format on which the specific conditions under which the shipment was controlled are recorded.

In fact, the steel companies ask all suppliers for a certificate to guarantee the absence of radioactive contamination and, in addition, an amount of the payment of the shipment is retained to pay the costs that might be generated in the case of detection of radioactive material.

2.10. Present situation

At present, there are 138 installations registered in the Protocol that belong to the metal recovery sector (106); the steel sector (27), or to the metal smelter sector (5). Detection portals have been installed in all the steelworks and major scrap warehouses, and smaller facilities have manual detection systems.

3. CONCLUSIONS

An overall system for the surveillance and radiological control has been established in Spain with the aim of preventing the presence of radioactive materials in scrap and, in the case of detecting such materials, to remove them from the stream as early as possible thereby preventing them from being processed. This system has the following characteristics:

- It is based on a specific legal framework;
- It is established in a Protocol of collaboration signed by the Ministry of Industry, Tourism and Trade, the Ministry of Public Works, the Nuclear Safety Council, the National Company for Radioactive Waste, S.A., the main associations of companies for the recovery of metals, steel producers and smelters, and the main trade unions. In this Protocol the parties commit themselves to establish a set of technical, administrative and procedural measures whose aim is the detection, segregation, characterization and safe management of detected materials;
- It considers, as a fundamental aspect, the training and the education in radiological protection of the personnel of companies involved in the metal recovery and smelting sector.

Experience has shown that even with the system as established by the Protocol there can be no relaxation in the efforts and concerns of the involved parties and, to that end, a permanent analysis of results and experience, by the technical commission set up for this purpose, to evaluate possible improvements, is one of the pillars of the system.

REDUCING UNCONTROLLED RADIOACTIVE SOURCES THROUGH TRACKING AND TRAINING: US ENVIRONMENTAL PROTECTION AGENCY INITIATIVES

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Abstract

The international metal processing industries are very concerned about the importation of scrap metal contaminated with radioactive materials. When radioactive sources fall out of regulatory control, improper handling can cause serious injury and death. There is no one way to address this problem and various US governmental and industry entities have developed radiation source control programmes that function within their authorities. The US Environmental Protection Agency's (EPA) mission is to protect public health and the environment. To ensure this protection, EPA's approach to orphan sources in scrap metal has focused on regaining control of lost sources and preventing future losses. EPA has accomplished this through a number of avenues including training development, product stewardship, identification of non-radiation source alternatives, physical tagging of sources, field testing of innovative radiation detection instrumentation and development of international best practices. In order to achieve its goal of enhanced control on contaminated scrap metal and orphaned radioactive sources, EPA has forged alliances with the metals industry, other Federal agencies, state governments and the IAEA.

1. EPA'S SCRAP METAL FOCUS

The EPA is concerned about the unnecessary risk that could be imposed on the general public from radioactively contaminated metals that may be incorporated into a variety of consumer products. As reports of radioactive contamination in recycled metal become more frequent, the potential for exposing the public increases.

Radioactive contamination can enter the metal supply in three ways:

— Sealed radioactive sources may fall out of regulatory control mechanisms when they become lost, stolen, forgotten or simply unwanted.
— Metal can be imported either as scrap metal, semi-finished or finished products.

— Metal can be released from licensed facilities; however, EPA has determined this material to account for only a small percentage of the annual supply of metal used in the USA.

Since the mid-1990s, EPA has been studying the risk associated with the recycling of slightly radioactive metals from Department of Energy (DOE) facilities and Nuclear Regulatory Commission (NRC) licensees. In 1997, the EPA considered promulgating a rule related to the release of this material. A technical analysis of the risk involved to various individuals from recycling of metals from nuclear facilities was conducted in 1997 and revised in 2001[1]. The results of these analyses showed the risks to be well within EPA's acceptable risk range. At that time, the EPA estimated that the amount of slightly contaminated metal from US nuclear facilities would comprise only 0.1% of the total US scrap metal supply. The EPA determined that the greatest threat to human health was not from the recycling of slightly contaminated metal from nuclear facilities but from lost, stolen or abandoned (orphaned) radiation sources.

In 1997, as a result of these risk assessments, the EPA redirected resources towards regaining control of orphan sources and determining methods to prevent the introduction of unwanted radioactive material, from both domestic and foreign sources, into the scrap metal supply. EPA's efforts are collectively called the Clean Metals Initiative. The EPA is working cooperatively with state and federal governments, national and international representatives of the metals industry, and international organizations to achieve this goal. The EPA is no longer considering promulgation of a clearance standard for scrap metal.

2. EPA'S SCRAP METAL STRATEGIES

The EPA's contaminated scrap metal strategy revolves around attacking the problem from a number of angles, while collaborating with other agencies and industry groups that are also addressing this issue. The EPA's strategy is two-pronged: (a) identifying and securing uncontrolled radiation sources and (b) preventing future losses. Activities relating to these two goals are presented below.

2.1. Identifying and securing uncontrolled radiation sources

2.1.1. Radiation source round-ups

In order to secure vulnerable sources, a national survey was conducted to identify all known abandoned sealed sources in the custody of the states or known to be surplus to the individual owner's needs. Based on this information, the State of Colorado successfully conducted a pilot roundup of 32 unwanted caesium-137 sources, which led to a nationwide source roundup, funded by NRC and DOE. This has further evolved into the current Conference of Radiation Control Program Directors (CRCPD)/DOE Source Collection and Threat Reduction (SCATR) Programme [2], which supports sealed source consolidation and disposal at the state level.

2.1.2. Port detection system

EPA, at the request of the US Customs and Border Protection, initiated a pilot study to investigate the need for, and the feasibility of, safeguarding against imported radiologically contaminated scrap metal arriving at seaports. The effectiveness of a grapple-mounted radiation detection system was tested. Because the detection unit is mounted on the inside of the crane grapple, the overall radiological response capabilities are greatly enhanced. This system allows each grapple load of metal to be monitored during the off-loading process, prior to loading on a barge, rail car or truck. Due to shielding, radiation monitoring of scrap in the hold of an ocean-going vessel is difficult, if not impossible. Field testing confirmed that the detector was robust enough to operate under the harsh conditions of the off-loading process.

Theoretical modeling confirmed that the grapple mounted detector increases the probability of detecting a source. The probability of detecting a cobalt-60 source, at the typical lower range of activities, anywhere in the grapple is approximately 92% [3]. The grapple-mounted radiation detection system, which can be operated and maintained by the port stevedoring companies, provides increased assurance against the import of contaminated scrap metal.

2.1.3. Training for the metal processing industries

There are a number of ways of finding lost sources, including monitoring, identification of exposure symptoms. Monitoring is the preferred method and many metal processing facilities have installed sensitive radiation detection systems and are locating and recovering sources. However, uncontrolled sources still enter scrapyards and metal processing facilities and, upon further investigation, a number of recurring mistakes and barriers to correct response were identified. Based on discussions with the metal processing industries, a CD-ROM training programme entitled Responding to Radiation Alarms at Metal Processing Facilities [4] was developed collaboratively with industry and the States.

Documented incidents at these facilities identified four areas where mistakes were consistently being made and where behaviour modification was needed. These included correctly passing the truck through the portal monitor, locating an appropriate remote area to isolate the truck, using a handheld survey meter correctly and the timely reporting of incidents. The student is challenged to solve a series of interactive ’missions‘ which are based on actual events at scrapyards and steel mills and serve to reinforce the training concepts.

2.1.4. Training for the demolition industry

Realizing that metal processing facilities represent the last line of defence against the introduction of unwanted radioactive materials entering the metal supply, the EPA addressed the origin of many of these materials — the demolition site. The EPA worked with the National Demolition Association to produce a CD-ROM training programme entitled Identifying Radioactive Sources at the Demolition Site [5]. Two groups were targeted for this training: the estimators who can locate gauges and devices containing radioactive sources during the initial walkthrough, prior to the initiation of demolition, and workers who may encounter potentially dangerous gauges and devices during actual demolition. The worker module utilizes the ’tool box‘ approach, which is a short learning session designed to be delivered at the job site.

The training programme presents opportunities at every step of the demolition timeline where radioactive gauges and devices can be identified and safely handled. A video of a facility walkthrough, combined with short, unscripted clips from demolition and radiation experts, help the student understand the physical characteristics of devices that may contain radioactive sources as well as the regulatory requirements for their safe handling and disposal.

2.1.5. Tritium exit sign training

The third EPA training programme focuses on a specific source, the tritium ‘exit’ sign, which has been shown to cause environmental contamination due to improper disposal at landfills. A 2005 report by the Pennsylvania Department of Environmental Protection identified tritium in 97% of the municipal landfill leachate samples analyzed (mean of 25 200 pCi/L (or about 1000 Bq/L)), leading to the conclusion that tritium ‘exit’ signs have been and continue to be illegally disposed of in landfills [6].

The EPA training programme, entitled Responsible Management of Tritium Exit Signs [7] presents procedures to encourage responsible handling and disposal of these regulated signs through raising awareness, promoting proper identification of the signs and outlining safe and proper procedures for handling, disposal and recycling of the signs.

2.2. Preventing future losses

2.2.1. Web-based assistance

Working with the States through the Conference of Radiation Control Program Directors (CRCPD), a web site [8] was developed that helps owners of unwanted material to find an acceptable outlet for the material. Licensed waste brokers and disposal companies are put in contact with source owners. A clearinghouse of information is available for those who have an unwanted source and for those wanting to obtain a source. Staff assistance is available to help identify an appropriate outlet for unwanted sources, as well as on-line commercial directories of waste brokers and transporters.

2.2.2. Identification of alternative technologies

Fewer radioactive source gauges and devices should lead to fewer lost, stolen or abandoned devices. To support this strategy, the EPA facilitates the development and acceptance of alternative technologies for industrial applications using sealed radioactive sources [9]. After evaluating the vulnerability of a variety of sealed source types, the EPA identified portable devices used in construction, i.e. soil moisture density gauges, to be most prone to loss or theft.

In a cooperative effort with the Gas Technology Institute, a utility industry research laboratory, six non-nuclear alternatives to these soil moisture density gauges were evaluated and validated [10]. One of the devices, the Clegg Hammer or Clegg Impact Soil Tester, was optimized for use in utility construction activities [11], and found to be incompliance with with American Society for Testing and Materials (ASTM) standards and adopted as an alternative soil moisture density technique.

Due to their portability, radiography cameras are also vulnerable to loss. The EPA, working with the Southwest Research Institute, conducted a validation study of ultrasound as an alternative to the radiography cameras for use in the testing of pipes and tanks in manufacturing facilities [12]. A market demonstration of pulsed X rays was also conducted as an alternative to the cameras [13]. Fixed gauges are not immune to loss — as documented by their detection in scrap metal. The EPA is looking into X ray backscatter and infrared and magnetic measuring devices as alternatives to fixed gamma and beta gauges.

2.2.3. Product stewardship

The EPA, in cooperation with the Product Stewardship Institute [14], is looking for solutions to the problem of loss of fixed gauges and tritium exit signs through involvement of all stakeholders in the life cycle of the radioactive material. Understanding the life cycle of radioisotopes aids in the identification of points in the production, use and end of life management chain where impacts to human health and the environment can be minimized. Product stewardship is incorporated into the process of transitioning from radioactive source devices to alternative devices. A stakeholder group of government, industrial (manufacturers and distributors) and non-governmental organizations was convened to promote improved management of radioactive tritium exit signs and fixed gauges.

2.2.4. Radioactive source tracking

The EPA and Oak Ridge National Laboratory (ORNL) are investigating the use of radio-frequency identification (RFID) technology to track and monitor radiological sources while in commerce. During Phase I, active RFID tags were embedded in Department of Transportation Type A radioactive material shipping containers. Two RFID tags systems were tested during 28 commercial truck shipments [15]. Based on the encouraging results of Phase I (maximum 77% probability of detection), 32 air express shipments of radiopharmaceuticals were conducted along the US East Coast. Two of the three RFID systems tested achieved above 75% probability of detection [16]. This project verified that RFID can be applied to the tracking of radioisotope shipments and that the technology is mature enough to be scaled into the nation-wide medical isotope supply chain. The development of a web based manifest system enhanced the data handling capabilities.

The EPA will be participating in the testing of RFID in the global radioisotope supply chain through a US–European Union Transatlantic Economic Council project in 2009 to start development of a framework for cooperation on the development of best practices for RFID technologies.

2.2.5. International recommendations for monitoring and response

In 2004, the United Nations Economic Commission for Europe (UNECE), with support from the EPA, embarked on a project to develop best practices for radiation monitoring in the metal processing industries. A questionnaire was sent out UNECE Member States that produced a snapshot of global regulatory infrastructure, monitoring, dispositioning, contracting and reporting related to scrap metal. Ten issues were identified based on an analysis of the questionnaire responses that could provide a framework for an internationally harmonized approach to monitoring scrap metal [17]. These issues helped define the Recommendations on Monitoring and Response Procedures for Radioactive Scrap Metal [18] published by the UNECE in 2006. These recommendations represent industry best practices and will support States in developing their own national scrap metal monitoring and response programmes. Harmonization at the international level should facilitate trade of scrap metal without comprising safety.

The Institute of Scrap Recycling Industries (ISRI) Radiation Task Force utilizes the UNECE Recommendations as a guide in their training courses. ISRI is a trade organization that represents 1600 scrap recycling companies of all sizes at more than 3000 facilities. Therefore, the incorporation of the UNECE Recommendations into their training programmes makes this information available to the majority of scrap facilities in the USA.

3. REASONS FOR SUCCESS OF THE EPA'S PROGRAMMES

The objectives of the EPA's Clean Materials Initiative are: (a) to secure uncontrolled radiation sources and (b) to prevent future losses. The EPA's Initiative has been successful for a number of reasons.

First, the EPA collaborates with the metal processing industry and demolition industries, State radiation authorities and other federal agencies responsible for radioactive material. This helps determine needs and develop value-added products that meet these needs. Working with industry also helps maintain the sustainability of the products.

Second, the EPA utilizes a wide range of techniques to encourage correct behaviour relating to the identification and handling of radioactive sources, such as training, searching for alternatives, and physically tracking sources when they are most vulnerable.

Third, in order to make an immediate impact, the EPA uses a voluntary approach rather than a regulatory approach. The EPA's goal is to create incentives for finding and properly dispositioning orphan sources and contaminated scrap metal.

There is still much work to be done in the USA. Disincentives still exist that do not encourage correct behaviour. Holding the finder responsible, rather than the polluter, may lead to found sources going unreported. A mechanism for providing incentives for properly handling and reporting a found source will go a long way towards removing uncontrolled radiation sources from the environment. Something as simple as a small monetary reward to workers who follow the proper response protocols or an award presentation to a facility that consistently handles found sources in a safe and legal manner would increase the control over these materials. Industry incentives send a strong message that management supports the proper handling of found radioactive sources.

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TRANSBOUNDARY MOVEMENT OF RADIOACTIVELY CONTAMINATED SCRAP METAL — LESSONS LEARNED

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Abstract

Starting in 1989, Bulgaria has undergone a comprehensive transformation of its economy and social conditions. Part of this process is related to the intensive privatizationprivatization that started in 2001. This privatization included facilities, as well as sites that use radioactive material for different applications — industry, medicine, agriculture, science, etc. The rapid change of property ownership and, in some cases, the resulting bankruptcy, has caused difficulties in tracing and identifying radioactive sources and materials and a deterioration of the system of safety, physical protection, etc. of radioactive material. In some cases, radioactive sources were stolen because of the value of their protective containers and sold for scrap metal. This led to the occurrence of different types of radiation incidents, mainly related to the discovery of radioactive sources in scrap metal. The consequences of these incidents include the risk of radiation exposure of the workers at scrap metal yards or reprocessing facilities and of members of the public and, in addition, radioactive contamination of the environment. The Bulgarian Nuclear Regulatory Agency (BNRA) has been responding to these incidents and has carried out a series of measures to improve the control over materials (e.g. activated or surface contaminated materials) and radioactive sources and to strengthen the preventive, monitoring, emergency preparedness and mitigating measures at facility, national and transboundary levels. This paper presents an analysis of the lessons learned by the BNRA and of the control of the transboundary movement of radioactively contaminated scrap metal through the territory of Bulgaria.

1. EVENTS INVOLVING RADIOACTIVELY CONTAMINATED SCRAP METAL

A number of events related to the detection of various types of radioactive material in scrap metal have occurred in Bulgaria. The total number of events for the 1998–2008 period (up to 15 July 2008) is 202 (see Fig. 1). Over 75% of the events are related to the discovery of:

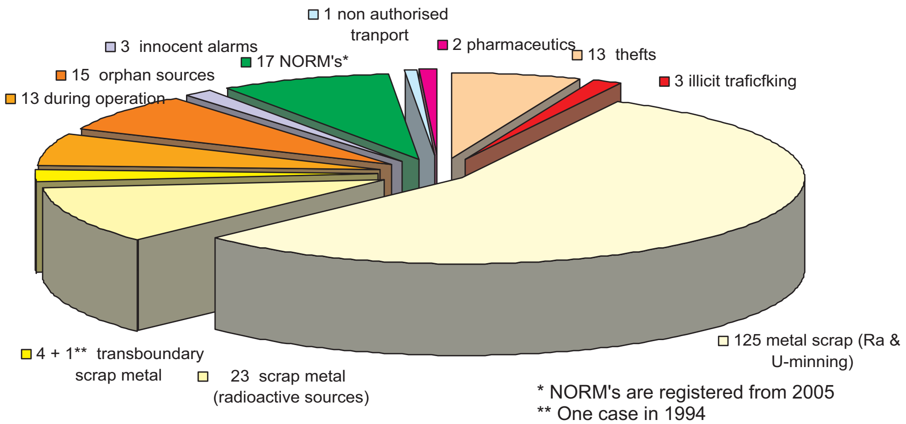

FIG. 1. Total number of events in Bulgaria for the 1998–2008 period (up to 15 July 2008).

(a) Radioactive sources and material, which had been accidentally collected with the scrap metal (these are usually appliances or parts covered with luminous fluorescent paint containing ^{226}Ra or ^{232}Th);
(b) Equipment and elements from uranium production;
(c) Equipment and elements containing high concentrations of naturally occurring radionuclides (NORM) (not from uranium production).

The remaining events (about 25%) are connected with detection of radioactive sealed sources, which were lost, found, stolen, illicitly trafficked, etc. The total number of events associated with radioactively contaminated scrap metal for the period 1998–2008 (i.e. up to 15 July 2008) is 152 (see Fig. 2). The statistics show that in 27 cases radioactive sealed sources were found, mainly ^{60}Co, ^{137}Cs, ^{241}Pu (static eliminators) and ^{226}Ra (sealed sources intended for marking roads using their luminescence properties). For this period, only 4 cases were associated with the transboundary movement of radioactive scrap metal. Another case was also detected earlier (in 1994). In total, 5 events involving the transboundary movement of radioactive scrap metal have been detected in Bulgaria.

The transboundary events mentioned above and the associated key lessons learned can be briefly described as follows:

1994

In 1994, recycled metal produced by the Bulgarian company Radomir Metals at the ferrous metal plant located in Radomir town was contaminated with ^{60}Co and was exported to the USA. The activity of the material was subsequently

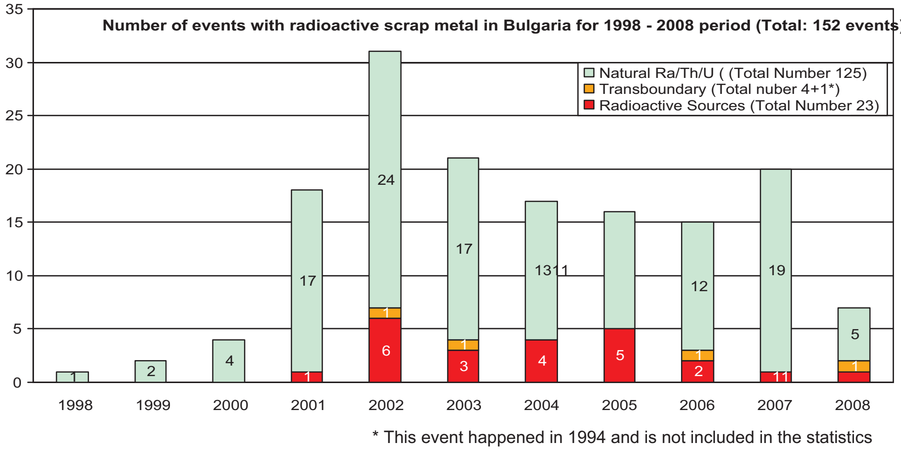

FIG. 2. Number of events associated with detection of radioactively contaminated scrap metal in the 1998–2008 period (up to 15 July 2008).

estimated to be 3.7 GBq. The reason for this contamination was assumed to be due to the melting of a radioactive source. The freight was received in USA. No radioactive contamination was found on the site or in the environment in Bulgaria. The workers were using individual protection equipment because of the specific working conditions with metals and no exposure or radioactive contamination was detected in Bulgaria during the radiation monitoring carried out at the time.

2002

In 2002, the only case of non-authorizedauthorized import of radioactive material was registered in Bulgaria. The radioactive material was a sealed source in a bale of metallic scrap imported from Romania. It was detected at the entrance to the Kremikovtsy smelting company. The bale was located, removed from the scrap metal and transported to the Novi Han repository (the State Enterprise Radioactive Waste — SERAW had not been created at that time). The radioactive source was identified as an illuminating gauge with a cover of ^{226}Ra paint. At present, the material is still stored at the Novi Han repository, located close to Sofia.

2003

In 2003, ash-heap lead contaminated with ^{137}Cs was found at the ‘Kombinat za cvetni metaly (KCM)’ — a non-ferrous metal plant located in Plovdiv. The scrap metal was exported and the contamination was detected when the freight

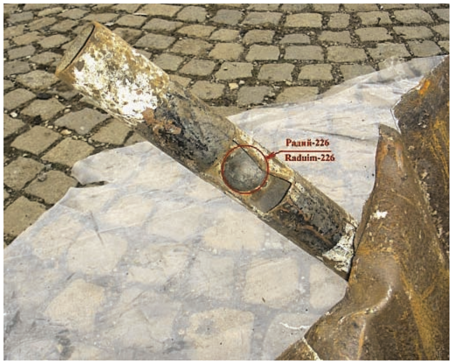

FIG. 3. ^{226}Ra radioactive sealed source (intended for marking roads because of its luminescence properties).

was monitored at a Chinese port before further reprocessing at a Chinese lead production plant. The activity of the material was estimated to be 110 MBq. As a result, the whole amount of contaminated ash-heap lead (about 400 t) was returned to Bulgaria and is presently stored under special conditions at the plant site. Probably a radioactive source was melted prior to export to China. No radioactive contamination was found at the site or in the environment of KCM. The workers are using individual protection equipment because of the specific working conditions with metals and no exposure or radioactive contamination was detected.

2006

In 2006, during radiation monitoring of a railway car carrying scrap at the border with Serbia, a radioactive source ^{226}Ra was detected. The railway car was transported back to Sofia (Railway Station Sofia-North) where the owner's scrapyard was located. The emergency team from the Regulatory Body (BNRA) and the Ministry of Emergencies (Civil Protection) partially unloaded the scrap wagon. It was found that a radioactive source with a semi-spherical shape was mounted on the upper part of a metal tube (size Ø = 50 mm and l = 1 200 mm) (see Fig. 3). The source was of ^{226}Ra (sealed sources intended for marking roads). The radiation dose rate was determined via contact surface measurement to be 19 μSv/h, which showed that there was no hazard for the workers, the public or the environment. The source was then isolated, packed in polyethylene and transported to the cargo company for temporary storage before disposal at the SERAW.

2008

In 2008, ash-heap copper contaminated with ^{241}Am was detected at the non-ferrous metal plant ‘Sofia Med’, located in Sofia. The ash-heap was exported to Greece, as Sofia Med is a Branch Company of ‘Halcore’ – Greece. The contamination was detected when a private monitoring company monitored a sample from the freight. The activity of the material was subsequently estimated to be 200 Bq/kg. This value is 5 times less than the limit of 1000 Bq/kg which can be melted in accordance with Regulation No. 25 of the Ministry of Health of Bulgaria. This Regulation also lays down the requirements for individual protection in case of chronic exposure as a result of production, use and trade with raw materials, products and goods containing radionuclides with enhanced concentrations. During the investigations, a small part of a radioactive source of ^{241}Am was found — but with a with low activity — about 4 MBq. It is likely that the source was used in a smoke detector. No radioactive contamination was found on the site or in the environment in Bulgaria. The Bulgarian workers were using individual protection equipment because of the specific working conditions with metals and no exposure or radioactive contamination was detected. It was not possible to find the country of origin of the radioactive source because the company works with imported raw materials from wide range of countries. The BNRA notified the Greek Atomic Energy Commission.

2. CONSIDERATIONS FOR MONITORING OF RADIOACTIVELY CONTAMINATED SCRAP METAL

The results of the investigations of all cases found during the period indicate that metal recycling plants, scrap metal yards and large traffic border checkpoints represent the key locations for the detection of radioactively contaminated scrap metal. On the basis of the analyses of the results performed, the measures indicated in Table 1 have been identified for the future with the aim of increasing the monitoring efficiency and also of preventing such events.

The analysis also shows that several techniques for detecting these sources are available. As part of the analysis, the most convenient places for the installation of the measurement devices were identified. Equipment for the purpose of radiation monitoring is available (with a large variety of technologies and prices). The equipment cannot, however, provide 100% detection. As scrap metal is processed, the loose metal is often converted through crushing or balling to a denser medium that can act as a radiation shield. Because of these features, from a technical viewpoint, the monitoring of incoming scrap metal at a recycling plant is the least effective place to perform this activity. Therefore, recycling

TABLE 1. MEASURES TO PREVENT EVENTS ASSOCIATED WITH RADIOACTIVELY CONTAMINATED SCRAP METAL

Site	Specific features	Strategy for risk reduction	Other measures
Small and middle sized scrap dealers	Significantly fragmented business; Large number of small scrap metal yards with limited financial resources and manual handling.	Small quantities of scrap metal – visual control by scrap metal yard personnel; Construction waste – visual control and standard liability agreement; Technology waste – standard liability agreement and preliminary site / scrap visual control by the receiving team.	Brochures and posters; Expert assistance for liability agreements; National seminars.
Large scrap dealers	Agent-type resellers of scrap	General: visual inspections and standard liability terms; in doubtful cases: use portable equipment or invite external service; Technology waste – standard liability agreement and preliminary control by the receiving team using hand-held monitors.	Hand-held detectors; Brochures and posters; Expert assistance for liability agreements National seminars.
Smelting companies	Significant business;Import and export of reprocessed scrap metal;Large potential financial losses in case of an incident;Large potential losses motivate companies to invest in radiation monitoring equipment.	Technology waste – standard liability agreement; Portal radiation monitoring detectors on entrances; Radiation monitoring on the shredder or at the conveyor; Additional radiation monitoring by using hand-held monitors	Hand-held detectors; Brochures and posters; Expert assistance for liability agreements; National seminars.
Border crossing check-points	Lack of monitoring places at the smaller check points – is not practicable to mount portal detectors; Redefinition of check-points due to joining European Union.	Definition of field control responsibilities: Border Police and Customs Service; coordination with neighbouring countries; Overall goal: full monitoring of incoming traffic by fixed portal detectors; Hand-held detectors for detailed surveillance and backup.	Brochures and posters; Expert assistance for liability agreements; Education and training; National seminars.

plants should require that radiation monitoring is also performed by the suppliers, such as scrap processors and scrap collectors, where the scrap metal is in smaller quantities, volumes and densities and can therefore be detected with a high probability. High performance fixed radiation detector systems are available commercially. They are usually installed at the weighing scale of the vehicles (e.g. trucks or railroad wagons) and sometimes at the shredder or at the conveyor. For most events involving the presence of radioactive sources, a serious difficulty encountered is concerned with the very small additional radiation level added to the background. Because of this, small sensitive hand-held detectors are inadequate for general vehicle inspection because they can only measure radiation well above the background level. They are however useful as a complementary technique after a radioactive source or material has been detected to locate it within the load.

Concerning the detection of radioactive sources or material by means of hand-held devices, a count-rate based alarm level is legitimate because an exposure or dose rate based level is not superior in any fashion for detection of the presence of radioactive material in scrap. In this matter, the USNRC and CRCPD (Conference of Radiation Control of Radiation Control Program Directors) [1] have recommended an alarm trigger level of 3 to 5 times background in order to exclude naturally occurring radioactive material (NORM) or modest amounts of medical waste and common consumer products from detection. It has to be pointed out that this detection method addresses only the issue of the presence of artificial radioactive sources in scrap, because it is not convenient to remove NORM from the scrap metal. The experience of Bulgaria shows that these recommended levels are too high. The first trigger level in Bulgaria is 15% (low level 1) above the natural background. A level 50% above the natural background is low level 2. The high levels are as follows: high level 3 is defined as 9 times the natural background and high level 4 is declared when 1.5 μSv/h is measured coincidently by both detectors. These levels are defined in Stomana - Inductry – Ltd – Pernik Emergency Response Plan for Actions in Case of Radioactive Contaminated Scrap metal [2].

Gamma detection can be performed by using a standard radiation protection rate meter connected to a sodium iodide scintillation detector probe by a cable of about 1 m in length. Most popular is the 2 inch (5 cm) diameter, 1/2 inch (1.3 cm) thick, sodium iodide scintillator. Increasing the diameter reduces the ‘missable’ activity but there is little point in increasing the thickness. Generally the detectors are set up with an energy of 60 keV. This is as much for the convenience of testing and calibration as for operational use. ^{241}Am is the most convenient and widely available low energy (60 keV gamma) source. The equipment is easy to use and relatively robust.

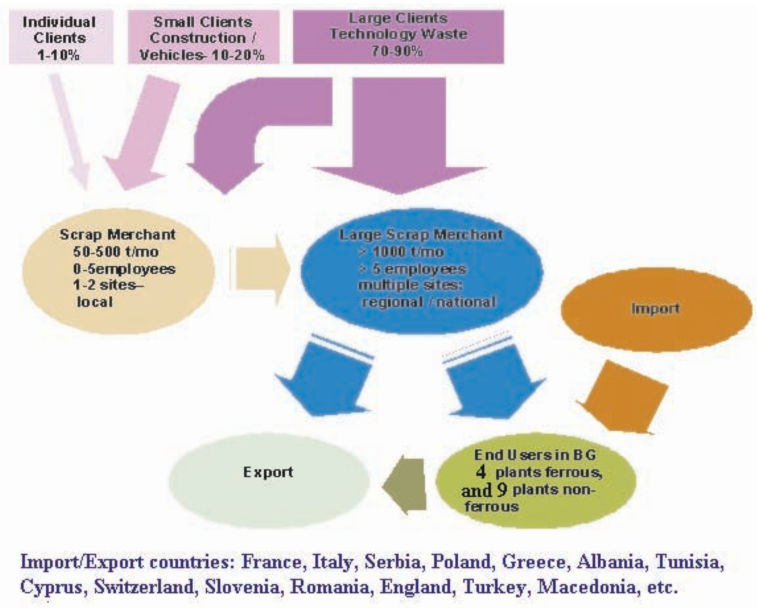

FIG. 4. Flows of scrap metal in Bulgaria.
The following metal plant end users (metals smelting companies) operate in Bulgaria (see also Fig. 5).

Based on the estimated results, BNRA in cooperation with the state competent authorities, is performing a series of measurements to improve the control over radioactively contaminated scrap metal and to strengthen emergency preparedness and response to radiation emergencies (events, incidents or accidents). The measures being implemented at present are summarized below together with the results achieved and lessons learned.

3. STRUCTURE OF THE METAL RECYCLING SECTOR IN BULGARIA

The structure of the metal recycling sector in Bulgaria is a hierarchical — pyramidal one. Scrap metal is collected via small-scale dealers and collectors, who sell the scrap to middle and larger scrap processing companies which later sell the scrap 'oven-ready' to the smelting companies (see Fig. 4).

The activities of all scrap collecting, storing and smelting companies are under the licensing regime controlled by the Ministry of Economy and Energy (MEE). The imported scrap is delivered directly by the scrap owner (foreign or national) to the big smelting companies.

Ferrous metals plants:	Non-ferrous metals plants:
1. Kremikovtsy, Sofia	5. KCM, Plovdiv
2. Stomana Industry, Pernik	6. Umicore Copper, Pirdop
3. Promet Steel, Burgas	7. OCK, Kardjali
4. Radomir Metals, Radomir	8. Rabar, Asenovgrad
	9. Alucom, Shoumen (Al)
	10. Alcomet, Pleven (Al)
	11. Supersplav, Plovdiv
	12. Sofia Med, Sofia
	13. Kurilo Metal, Novi Iskar

FIG. 5. Location of metal plants (metal smelting companies) in Bulgaria.

4. PREVENTION, DETECTION AND RESPONSE TO TRANSBOUNDARY MOVEMENT OF RADIOACTIVELY CONTAMINATED SCRAP: LESSONS LEARNED

— *First lesson learned — Special articles should be developed and promulgated in the legislation regulating the issue of radioactively contaminated scrap metal. The legislation should clearly allocate the responsibilities of involved organizations*

In 2002, a new Act on the Safe Use of Nuclear Energy (ASUNE) was promulgated. According to this Act, the BNRA is not a competent authority for scrap metal collecting, storing and smelting companies since these companies do not use ionising radiation and therefore they are excluded from the scope of ASUNE. However, in case of detection of radioactively contaminated scrap metal, the BNRA becomes the competent authority and the main task is to ensure compliance with the legislation, i.e. the Act and the supporting legislation. To facilitate these activities some legislative measures in secondary legislation (Regulations) have been introduced.

The ASUNE [3] prohibits the import of radioactive waste into the country, except in the cases of:

— Re-import of recycled disused sealed sources and sources of ionising radiation manufactured in Bulgaria;
— Import of waste from (re)processing of materials executed as a service in favour of Bulgaria or of the Bulgarian legal entity.

The secondary legislations contains:

— Categorization of the radioactive sources;
— Requirements for development of on-site and off-site emergency response plans and emergency procedures;
— Requirements for the development of guidance;
— Requirements for the training of the personnel, as well as the emergency response personnel.

The categorization of the sites and activities in threat categories, as well as sites at risk such as reprocessing facilities, border check points, scrapyards, etc., is in compliance with the IAEA Safety Series No.GS-R-2 Preparedness and Response for a Nuclear or Radiological Emergency [4]. The scrap metal processing facilities are covered by the requirements of the Regulation for Emergency Planning and Emergency Preparedness in Case of a Nuclear or a Radiation Accident [5]. This Regulation specifies the facilities, sites and practices to be categorised in one of the five threat categories. The lowest threat category, Category V, includes the conventional waste facilities, the scrap metal storage facilities, the metal processing facilities and national border checkpoints [6]. Category V is defined as practices not involving radioactive sources, but where, as a result of an accident or an incident in facilities of threat Categories I, II, III and IV or in the case of a transboundary release, there is a possibility of contamination with radioactive substances. In this case, a possibility exists that the projected doses may exceed the dose limits for the general public, determined for normal operations in the national radiation protection standards and could require implementation of radiation protection measures. It is therefore required that each scrap metal storage and processing facility develop and maintain an on-site emergency plan (or a procedure).

In addition, in accordance with the national legislation (i.e. the Act of the Ministry of Internal Affairs), the General Department Border Police exercises control at the border access points over the movement of people, vehicles and freights as well as over the import of radioactive materials, including scrap metal [6]. The control is implemented on land, air, rivers and sea. The Border Police have the necessary personnel for the fulfilment of these control activities. Each duty shift of the Border Police includes police officers who have the necessary training in controlling freights and vehicles and are equipped with portable equipment for radiological monitoring. Interactions with other bodies and agencies are provided for in the national legislation and sometimes in joint documents.

Each of the smelting companies is required to prepare a scrap delivery contract with the scrap owner, which includes several conditions connected to the presence of radioactive contamination or radioactive sources in the scrap metal, such as:

— Declaration provided by the suppliers that the scrap is free of dangerous waste (including radioactive);
— If there is dangerous waste, the supplier is considered to be the owner, which means that the supplier has the obligation to pay all the expenses for collection, transportation and safe storage of the radioactive source or radioactive contaminated scrap metal.

The radioactive source or material that has been found in the scrap metal or radioactively contaminated scrap metal is the possession of the scrap metal owner and he/she is obliged to cover all expenses for the resolution of the emergency. In cases where the detected radioactive scrap metal is of no further use, it is declared as radioactive waste.

In any case, the radioactive scrap metal is sent for storage to the radioactive waste repository ‘Novi Han’ operated by the SERAW and the BNRA keeps records of the relevant information.

— *Second lesson learned — Special guidance for prevention, detection and response in case of radioactively contaminated scrap metal should be developed and distributed to all parties concerned and the relevant staff should be trained*

The increasing number of incidents related to the discovery of radioactive sources and materials in scrap metal is a global problem. On account of this observed increase, the United Nations Economic Commission for Europe (UNECE) has recommended relevant technical and organizational measures for preventing radiation incidents with scrap metal [7]. With respect to these recommendations, in 2007 the BNRA developed a special guide 'Guideline for prevention, detection and response to radiation emergency in case of the discovery of radioactive material in scrap metal' [8]. Based on the guideline a short leaflet was developed with instructions on what measures to perform. The guideline contains information about the competent authorities and their responsibilities, as well as useful information about radioactivity and measurement equipment, (including photographs) for the scrap metal operators and shipping organizations. The Guideline was distributed to all concerned parties and was published on the BNRA web page (www.bnra.bg). BNRA organises meetings with the representatives of the scrap metal organizations and other relevant companies to discuss the issues of radioactively contaminated scrap metal.

— *Third lesson learned — Radiation monitoring equipment for discovering radioactively contaminated scrap metal should be available and emergency response plans or procedures should be developed*

As a result of the first lesson learned, automated systems for radiation control of the received scrap were installed at the major metallurgical plants (Kremikovtsy — Sofia, Stomana Industry — Pernik, KCM — Plovdiv, Sofia Med — Sofia, etc.). The companies working with scrap have undertaken measures for preventive radiation control during storage, shipment and marketing of scrap by using their own radiometric equipment and/or the services of organizations licensed by the BNRA to perform such activities. Internal emergency plans (procedures) have been developed and sites for the isolation and handling of radioactively contaminated scrap have been identified. The companies licensed by the BNRA are also required to notify the competent authorities immediately after they discover any radioactive sources or radioactively contaminated material in scrap metal.

The strict border controls with respect to the detection of goods and materials with increased radioactivity and the developed system for interaction between the competent authorities in Bulgaria have contributed greatly to the prevention of the illegal import, export and traffic of nuclear or radioactive materials and, respectively, to the prevention of radiation incidents in the country.

In 2007, the BNRA and the Border Police Directorate-General (Ministry of Internal Affairs — MIA) signed an agreement for cooperation in this field. A programme was developed for the performance of joint inspections at the border checkpoints (BCPs) in the country, and procedures were introduced for responding to the detection of illegal imports, exports or trafficking of nuclear or radioactive materials and to the discovery of ‘orphan’ radioactive sources.

In 2007, the BNRA and Border Police General Department, jointly with the European Union (EU), the IAEA and the US Government, implemented projects for equipping the BCPs with stationary and portable detectors for monitoring the radioactivity of cargoes. At the end of 2007, the BNRA, in coordination with the Border Police General Department, initiated a project financed by the EU for the supply and installation of radiometric monitoring equipment in three BCPs located on the western border.

All BCPs in the country have been provided with mobile measuring equipment for the detection of sources of ionising radiation, and automated stationary appliances for radiation control have been installed at three border checkpoints. The obligations of the checkpoint officials related to the exercise of radiation control and response in cases of incidents are regulated by the relevant legislation. The training of Border Police officials in the effective performance of radiation control has been organised. The emergency teams of the regional structures of the Ministry of Emergencies and the Regional Inspectorate of Protection and Control of Public Health acting jointly with the Border Police upon detection of radioactive scrap metal are also equipped with the necessary appliances for radiation measurement.

In addition, in 2007, the BNRA, the MIA and the SERAW completed international projects financed by the IAEA, EU and the USA for enhancing physical protection at hazardous sites and for ensuring the safety of high-level sources.

When it is necessary to remediate situations resulting from emergencies with radioactive scrap metal [8], an interdepartmental emergency team is gathered, with the participation of the BNRA, the Ministry of Health (MH), MIA, General Department ‘National Service Civil Protection’ (CP) to the Ministry of Emergencies (ME) and SERAW depending on the specific situation (see Fig. 6). The radioactive sources and radioactively contaminated material are collected and isolated temporarily in appropriate places (i.e. special designated places on-site in the scrapyard, at the border check point or other places), after which they are transported to the SERAW for safe storage. In these cases, the IAEA and the competent bodies of the concerned countries (in the case of imported scrap metal) are notified according to established procedures. The documentation of the events related to emergencies with radioactive scrap metal is stored and archived by the BNRA.

A special module, ‘Incidents with Radioactive Sources’, has been created in the BNRA’s integrated information system in which all events related to

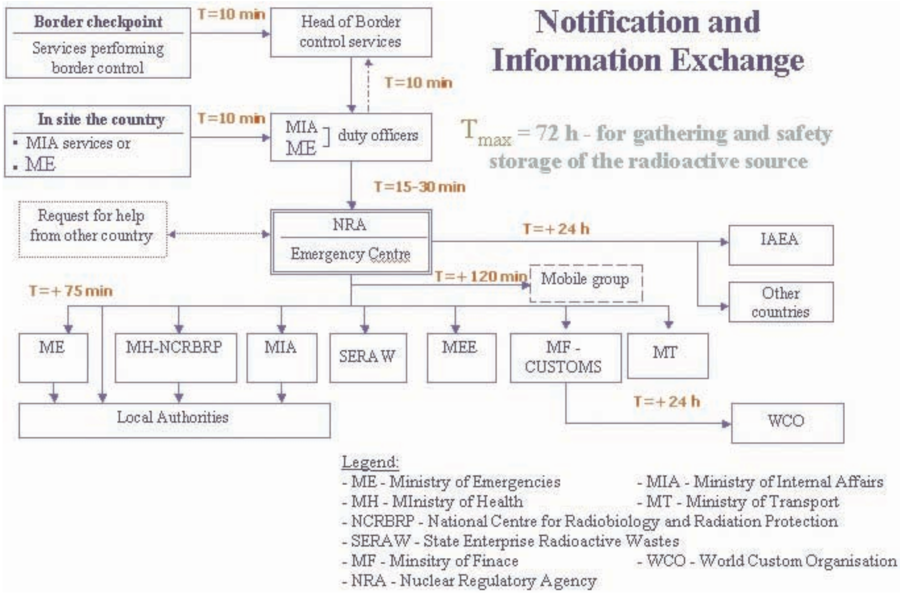

FIG. 6. Structure of the interdepartmental team for emergency response for incidents involving radioactive scrap metal.

radioactive scrap metal (and other events) are registered. The BNRA regularly publishes updated information about the radiation incidents that have occurred in the country, on its website as well as in its annual reports.

When a deviation of the natural gamma background is detected, the border police officers divert the vehicle, the freight and the person for additional measurement and inspection of the freight [9]. The head of the border access point notifies the regional department of Civil Protection (ME) and the Regional Inspectorate for Public Protection of the Ministry of Health. Representatives of these organizations conduct precise measurements and analyses for determination of the freight's radionuclide content.

If a radioactive source or radioactively contaminated material is found in scrap metal, actions are undertaken in accordance with the National Emergency Plan, Chapter III 'Actions in case of radiological emergency (radioactive contamination)', relevant guidance and emergency procedures [9]. In this case, the affected vehicle is directed to an area designated for that purpose within the border access point boundary (or on-site at a scrapyard) and a safety perimeter is created around it. The Civil Protection and Ministry of Health staff localize the exact position of the source and undertake actions for its safe retrieval and shipment. BNRA and other competent bodies are informed and, if necessary, their assistance is requested. The radioactive source is owned by the freight owner, who is obliged to cover the expenses for the management of the emergency. The source is a subject of criminal investigation and, as such, is stored in a specially designated facility until the completion of the investigation. Once the criminal investigation is over the source is returned to the country of origin and the responsibility is taken on by the owner.

When radioactively contaminated scrap metal that is suspected to be of Bulgarian origin is detected outside Bulgaria, the BNRA must be notified. The BNRA, in turn, notifies the Ministry of Internal Affairs and other competent authorities. Before accepting the source back, Bulgaria requires evidence that it really originates from the country. If such evidence is provided, the BNRA issues a permit for import of the source and establishes control over its further movement. The owner of the source is the company that owns the freight in which the source was detected and it bears the responsibility of covering the corresponding expenses.

5. CONCLUSIONS

Bulgaria has developed and is currently implementing a national system for the management of radioactively contaminated scrap metal, including situations involving transboundary movement.

The BNRA is planning, in the near future, to organise meetings and seminars with the representatives of the scrap metal companies, as well competent state authorities, in order to discuss the issues of radioactively contaminated scrap metal.

Legislative requirements have been put into full compliance with EU legislation and the internationally adopted safety requirements of the IAEA and the best practices of other countries.

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ASSIGNMENT OF RESPONSIBILITIES IN THE MANAGEMENT OF SCRAP METAL IN BRAZIL

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Abstract

This paper gives an overview of the activities of the National Commission of Nuclear Energy (CNEN), as the Brazilian regulatory authority responsible for licensing, inspecting, controlling and regulating all practices involving sources of ionizing radiation. The activities of the main departments of CNEN responsible for taking care of the practices and sources are described, especially those related to orphan sources and radioactive material in scrap metal. Finally, although Brazil does not yet have the necessary infrastructure to take care of the scrap metal issue, through the joint action of the relevant departments of CNEN it is hoped that the appropriate steps can be taken to build a national protocol, following the examples of other countries, especially Spain.

1. INTRODUCTION

In Brazil, there is not yet an effective system for controlling the scrap metal and recycling industry. There are individual initiatives from several departments of the National Commission of Nuclear Energy (CNEN), the Brazilian regulatory authority in nuclear matters, but a coordinated approach to achieve a harmonized and effective response with the involvement of third parties, especially the steel and metal industries (ferrous and non-ferrous), is lacking.

This work considers the actions already put into place by the General Coordination of Medical and Industrial Facilities (CGMI), the department of CNEN responsible for the licensing and controlling of radioactive facilities in industry, medicine, research, commerce and service providers. Most of the sources in Brazil are covered by this department and this area accounts for most of the recorded accidents as a result of activities such as industrial radiography and medical radiotherapy. These two areas, in particular, call for stringent regulatory control, in order to reduce the occurrence of orphan sources, and consequently, radioactive material appearing in scrap metal.

The paper also describes the fostering of a closer contact among the departments of CNEN, which have responsibilities directly or indirectly over scrap metal and the recycling industry, listing the main actions under way, as well as the projects to be started, for each of these departments, so as to elaborate an action plan in the medium to long term.

2. RESPONSIBILITIES OF THE REGULATORY AUTHORITY

2.1. General structure of CNEN

CNEN is a federal autarchy created by Law No. 4118 [1], linked to the Ministry of Science and Technology, and whose responsibilities are described by Laws No. 6189 [2] and No. 7781 [3]. The range of its responsibilities is very broad, including regulating, licensing, controlling and inspecting as well as research. Its mission is 'To facilitate the secure and peaceful use of nuclear energy, to develop and make available nuclear technology for the benefit of the population' [4].

CNEN has branches throughout the country: it is organized through the two technical directorates, the Directorate of Radiation Protection and Nuclear Safety (DRS) and the Directorate of Research and Development (DPD).

The DRS coordinates, regulates and oversees the execution of the activities of licensing and inspection of nuclear and radioactive facilities, inspection of mining and benefiting industries of ores containing uranium and thorium, nuclear safety, radiation protection, safeguards, physical protection, controlling of nuclear and radioactive materials and ores of strategic interest and certification of professionals in these fields. Although there is no direct responsibility over the controlling of scrap metal and recycling industry, DRS has a direct responsibility for the control of orphan sources through licensing and controlling nuclear and radioactive facilities and mining industries.

The DPD plans, orientates and coordinates the execution of the activities of research, development and nuclear technological and ionizing radiation applications, and is responsible for education and training concerning technical and scientific specializations and graduation in the nuclear field.

Although it is not directly concerned with scrap metal, the DPD is involved in cooperation work with DRS, and, for example, it contributes to the non-proliferation of orphan sources by placing orphan sources in secure storage facilities in the DPD institutes and regional centres, namely the Institute of Energetic and Nuclear Research (IPEN), the Institute of Nuclear Engineering (IEN), the Center of Nuclear Technology Development (CDTN), the Regional Center of Northeast (CRCN-NE) and the Regional Center of Mid-West (CRCN-CO).

Concerning Brazilian regulations, CNEN elaborate its own norms and they are divided into six groups, which prescribe the activities of its two technical directorates (DRS and DPD) and respective coordinations, divisions and services, namely: Group 1 – Nuclear Facilities, Group 2 – Physical Protection, Group 3 – Radiation Protection, Group 4 – Nuclear Materials, Minerals and Ores, Group 5 – Transport of Radioactive Materials and Group 6 – Radioactive Facilities.

2.2. Responsibilities for the licensing and controlling of radioactive facilities

The General Coordination of Medical and Industrial Facilities (CGMI), through its two divisions, Division of Medical and Research Applications (DIAMP) and Division of Industrial Applications (DIAPI), is responsible for the licensing of radioactive materials applied to medicine, research, industry, commerce and service providers, as well as for the control of the sources related to the associated practices.

Concerning regulation, the general aspects of CGMI activities are controlled by at least three norms: the Basic Radiation Protection Standards [5], the Radiation Protection Service [6] and the Licensing of Radioactive Facilities (the main norm exclusively related to CGMI activities) [7].

In relation to licensing, the emphasis is on stringent processes in the safety assessment phase for the major risk facilities, completed by inspection and auditing actions. In exercising control, all the available actions and tools for controlling radioactive sources are applied, be it to those produced and distributed throughout the national territory, or to those imported from foreign countries.

The Integrated System of Foreign Trade (SISCOMEX) is an IT tool used in the control of Brazilian foreign trade, and, in relation to the interests of CNEN, it is applied to the import and export process of products containing radioactive material, strategic raw material for the country or radiation generator equipment. This system is used by several Brazilian governmental authorities, among them, CNEN, through partnership with the institutions responsible for the management of this system, namely: the Secretariat of Foreign Trade (SECEX), linked to the Ministry of Development, Industry and Foreign Trade; the Secretariat of Federal Revenue of Brazil and the Central Bank of Brazil, both linked to the Ministry of Finance. The actions of licensing and controlling together establish regulatory control over practices and sources, decreasing the probability of sources becoming orphaned and consequently, appearing in scrap metal.

In medical applications, specifically those which may give rise to radioactive materials appearing in scrap metal, for example, due to sealed sources used in brachytherapy (LDR and HDR) and radiotherapy, specific control actions are employed, not only to avoid the occurrence of accidents involving patients, but also to decrease the frequency of orphan sources, and consequently, radioactive scrap metal.

Besides the aforementioned regulations, there are specific norms applying to each broad application in medicine, namely the Safety and Radiation Protection Requirements to Nuclear Medicine Services [8] and the Safety and Radiation Protection Requirements to Radiotherapy Services [9].

There used to be a problem with radium-226 needles in Brazil. However, they have generally been replaced by new brachytherapy techniques over the years. The radium sources were collected and placed in approved storage facilities. Some caesium-137 tubes are still used in a few hospitals whose users insist on continuing to use them, but around 80% of these sources have already been collected by CNEN and stored at the storage facilities in DPD institutes. This action was prompted by international recommendations concerning accidents that had occurred worldwide as a result of the use of obsolete brachytherapy sources [10].

CNEN exerts a strict control over the decommissioning of radiotherapy facilities so that the final destination of the sources used in these practices is known. This has been done in order to avoid situations in which sources are abandoned without the due information being provided to the competent authorities, as happened in the case of the Goiania accident.

In industrial applications, the area likely to cause most concern is industrial gamma radiography. In Brazil, mainly iridium-192 and selenium-75 sources are used for on-site facilities and cobalt-60 for enclosed facilities. The service providers, around 20 companies, together have a total inventory of about a hundred sources spread throughout the country. For this reason, stringent control is exerted over these companies, through the inclusion of special conditions in their authorizations for the operation of these sources, specifying the maximum capacity of the sources commensurate with the radiation protection system provided in the operations (calibrated survey meters and qualified personnel in adequate numbers proportional to the source inventory) and the licensed capacity of the storage for the sources when not in use.

These companies are required to notify CNEN monthly regarding all the contracts they receive to provide industrial radiography services at third parties' premises, with all information about these facilities included. There can be critical situations when these sources are to be used in inhabited areas and on public roads, as in the case of gas and oil pipelines. In these cases, the special conditions in the authorizations are even more constraining and specific for each individual service; the related notifications to the regulatory authority are similar to the conventional operations using gamma radiography sources, but with specific information to be provided about these services.

In oil prospecting, there are more than ten operational bases belonging to the two biggest multinationals in this field; in addition, there are some other companies of medium and small size, in the fields of well logging and cementation, making use of caesium-137 and neutron sources, as well as low activity sources used for calibration of related equipment.

In the nuclear gauging field, there are around 800 gauges in use. Some are being used in severe work conditions, such as exposure to high temperatures which could produce accidents involving the melting of the source shield thereby causing the production of contaminated material and a potential source of contaminated scrap metal — if there is not stringent control over the facility.

Industrial radiation facilities, although belonging to the major risk category, generally do not cause a great deal of concern when compared to the others. This is because of the defence in depth and safety culture approaches adopted when designing, constructing and operating these facilities and because of the care given by the regulatory body in licensing them. During decommissioning, it is necessary to be sure that all activities are carried out under proper control until the sources of cobalt-60 have been repatriated or taken to a intermediate storage facility accepted by CNEN prior to their final destination. Otherwise, the orphan sources or worse, radioactive scrap metal, coming from the mismanagement of this decommissioning could lead to an accident of enormous proportions.

A database exists, controlled at the regional level, in which every source and practice involving radioactive material is recorded. This system makes it easier to identify potential orphan sources when a notification is received through the system of response to radiological events, coordinated by Division of Response to Radiological and Nuclear Emergencies.

2.3. Responsibilities for waste management

The Division of Waste (DIREJ) of CNEN has a historical involvement in collecting radioactive waste. It has collected many radioactive sources, coming from industrial facilities, hospitals, universities and others, thereby decreasing the frequency of the occurrence of orphan sources in the national territory. Currently, this collection is made by the institutes and regional centres linked to DPD; however, DIREJ still maintains a database with all the information on the collection of radioactive sources and waste over the last years.

2.4. Responsibilities for safeguards and physical protection

The Coordination of Safeguards and Physical Protection (COSAP) controls and inspects all the nuclear material existing in the country, as well as being responsible for the licensing of facilities in relation to the control of nuclear material and physical protection.

This coordination is also responsible for being the point of contact in Brazil for the IAEA, since Brazil adhered voluntarily to the International Traffic

Database (ITDb). In this way COSAP receives notifications on events of illicit trafficking occurring abroad, allowing the proper analysis of this information, and provides feedback to IAEA on similar events occurring in Brazil.

It also represents CNEN in a regional working group for prevention, detection and response to events of illicit trafficking of nuclear and radioactive material, in which Brazil acts together with the other countries belonging to the independent free-market zone in South America (MERCOSUL), bringing together regulatory and inspection authorities in the nuclear and radioactive areas, security forces, intelligence and border control agencies.

At the national level, COSAP acts in a similar way, together with Brazilian competent authorities, controlling and inspecting throughout the country and receiving notifications from the Division of Response to Radiological and Nuclear Emergencies each time there is some evidence of illicit trafficking.

These actions, direct or indirect in nature, contribute to decreasing the frequency of radioactive material appearing in scrap metal, because many orphan sources are found as a result of the existing system and recovered, stored safely and securely or repatriated. In addition, they allow for a constant evaluation of results and for the establishment of future strategies in the prevention, detection and response to events involving illicit trafficking of nuclear and radioactive material.

2.5. Responsibilities for the response to radiological emergencies

The Division of Response to Radiological and Nuclear Emergencies (DIEME) is located in the Institute of Radiation Protection and Dosimetry (IRD), a supporting institute for licensing. The contribution of DIEME is important to the subject discussed in this paper, since its activities are related to actions such as the rescue of abandoned, lost and stolen sources, decontamination of facilities and the recovery of affected areas due to accidents. This division is also responsible for the training of several institutions concerning their roles in emergency situations, through courses on response to radiological and nuclear emergencies.

2.6. Responsibilities of the institutes of CNEN

As previously mentioned, the institutes of CNEN, which are linked to DPD, have as a main responsibility, collecting and storing, in a safe and secure way, the radioactive waste coming from applications of nuclear energy throughout the country, and so they act as intermediate storage facilities for low and medium level waste.

The DPD has been investing in the reform and enlargement of these storage facilities, to provide for the increasing amount of waste, orphan sources, contaminated materials (potential sources of scrap metal). It is also responsible for the management of the one and only definitive disposal facility in Brazil, sited in Abadia de Goiás, state of Goiás, in the Midwest of the country.

3. RESPONSIBILITIES OF THIRD PARTIES

Initial contacts have been made with some industries. It has been observed that a few the steel and metal businesses of large and medium size have already installed some radiation detection systems (portals and other kinds) in their facilities, with the goal of detecting the presence of items contaminated by radioactive materials, or even the presence of orphan sources, among the metallic scrap received as raw material. Despite these voluntary acts of some of the steel and metal industries, there are still no requirements by CNEN to guide these industries.

In the long and medium term there are good prospects for coordination provided that the right partnerships can be found. Potential partners are some secretariats belonging to Brazilian Ministries, which can help in many ways in introducing the philosophy of security and safety in the scrap metal and recycling industry, by promoting the introduction of radiation detection systems at strategic points, like ports and airports, in large industries in the steel and metal business; by helping to identify associations or any kind of organization which brings together medium and small sized recycling businesses, and also the scrapyards.

4. FINAL REMARKS

The actions and projects mentioned here have been fruit of years of hard work at CNEN, trying to improve increasingly the methodology of licensing and control, according to the risk of practices as recommended by the IAEA [11], in order to avoid the occurrence of new accidents in Brazil. But two of them deserve to be highlighted because the main concern is to improve the control of sources which are beyond the reach of CNEN by making use of third parties to share actions and responsibilities.

The first one is the System of Investigation of Radiological Events (SINAER), which, among other actions, consists of a book which provides all the necessary information for the identification of sources that might have been lost, abandoned or stolen, according to their related practices and also instructions for assuring safety and security. This book was distributed throughout the country, in numbers commensurate with the number of facilities and radioactive sources, to guide the actions needed for the collection of sources [12].

The other project is the Practical Guide in Radiological Safety for Industrial Radiography, which was distributed to the main contractors in the country, especially the Brazilian company responsible for all the oil exploration and production, PETROBRAS. This booklet contains basic information on radiation protection, as well as on the safety and security measures for dealing with radioactive sources [13].

5. CONCLUSION

Despite the fact that Brazil does not have specific arrangements for managing the problem of radioactive material in the scrap metal and recycling industry, it is clear that CNEN is in control over the sources and practices existing in the country. It does this by stringent licensing, inspections and audits, completed by the control of commerce, including domestic and foreign trade.

Brazil also has a good record in collecting potential orphan sources. Sources no longer in use are collected and stored at institutes belonging to CNEN. In addition, there is a system of response to radiological emergencies which receives notifications regarding orphan sources, contaminated material and other kinds of potential scrap metals.

Stringent measures are employed in decommissioning nuclear and radioactive facilities, especially those of major risk classification.

Nevertheless, in addition to all of these actions, it is recognized that more can be done by developing a coordinated mechanism in Brazil for managing the problem of radioactive material entering scrap metal involving all potential stakeholders along the lines of the national protocol of Spain and it is hoped that this will be achieved in the coming years [14].

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FRENCH REGULATORY FRAMEWORK FOR THE RECYCLING/REUSE OF NUCLEAR WASTE AND THE DISMANTLING OF GEORGE BESSE GASEOUS DIFFUSION PLANT

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Abstract

The regulatory framework in France governing the management of materials containing low levels of radionuclides is described. The plans for the management of the materials arising from the dismantling of the Georges Besse Gaseous Diffusion Plant are described as an example of the application of the regulations.

1. INTRODUCTION

In the near future, decommissioning operations will increase in France and the volume of very low level waste will increase substantially. For this reason, studies are being undertaken to determine if some materials which are potentially contaminated could be recycled for reuse, taking into account the French regulatory framework. The objectives of this presentation are the following:

- To present the French regulatory framework concerning the recycling/reuse of materials coming from nuclear installations;
- To provide a perspective in this context in relation to steel recycling issues based on the dismantling of George Besse gaseous diffusion plant, located in Pierrelatte.

2. REGULATORY CRITERIA

2.1. International guidance

The IAEA and the European Commission (EC) have made recommendations dealing with exemption and the free release of low level contaminated materials. These international organizations propose the use of threshold limits based on the following radiological criteria: a maximum individual dose of 10 micro Sv/a and a maximum collective dose of 1 man.Sv/a. The evaluation of possible exposure scenarios has been used to establish radionuclide specific concentrations in materials based on these criteria. In addition, guidance has been given on the application of the threshold values.

2.2. French regulatory framework

2.2.1. Exemption

The Public Health Code in its article R 1333.18 takes the main concepts from the EURATOM Directive 96/29. In particular, exemption thresholds in France are similar to those of the EURATOM directive; one of the two thresholds (activity concentration or total activity) must be respected. On the other hand, French regulations are stricter than the European Directive in that, in the case of bulk activity criteria, the weight of the substances should be less than one ton.

2.2.2. Free release

In France, there are no dose criteria and no release threshold for very low level contaminated materials. The Public Health Code forbids “the use of materials and waste issued from a nuclear activity for consumer and construction goods when those are contaminated or potentially contaminated”. Nevertheless, a temporary exception from the law is possible if it is justified by advantages with regard of health risks. These temporary exceptions are validated by a health minister’s decree after consultation with the National Safety Authority and the Council of Public Health. Case by case recycling is therefore theoretically possible. However, the use of these exceptions is nowadays very limited.

3. NATIONAL MANAGEMENT PLAN FOR RADIOACTIVE WASTE AND MATERIAL

3.1. Context

The Parliamentary Office in charge of scientific and technical choices proposed to the government on March 8th 2000 that a national plan for the management of radioactive waste and materials be developed. In Spring 2003, a working group composed of representatives from the administration, from the regulatory body (ISRN) and from operators of nuclear installations met to brainstorm about the feasibility of such a plan and its methodology. During a council of ministers meeting on 4th June 2003, the government decided to launch the elaboration of this plan (called PNGMDR — National Management Plan for Radioactive Waste and Material). The plan was applied until 2006 under the supervision of ISRN. The Act of 28th of June 2006 pointed out the key role of such a plan and required its review every three years. The last version (agreed by the decree 2008-357 of 16th April 2008) must be revised in 2010.

3.2. Very low level waste case

The PNGMDR provides the general framework for defining operational routes for the management of radioactive waste and, in particular, the management of very low level waste (VLLW). The PNGMDR document recalls the decision of the Safety Authority in 1990 not to follow the principles of a free release threshold but to develop a dedicated management route for VLLW coming from nuclear installations. In the chosen policy of the Safety Authority, the difference between conventional and nuclear waste is based on the zoning of a facility and not on the basis of radiation measurement. Several arguments are used to justify such a policy:

— There is no possibility to demonstrate the exhaustively that all of the possible scenarios have been considered in determining the universal free release threshold by international organizations;
— These scenarios are generally linked to dilution coefficients. For instance, dilution of the very low level steel flow coming from nuclear industry by the non-nuclear recycled steel flow. The situation of little or no dilution may occur when dealing with a major decommissioning programme;
— The selected values for free release threshold are very low and can be practically achieved by measurements on small amounts of potentially contaminated materials. However, these measurements are very difficult and are not compatible with the huge amounts of waste from large decommissioning projects;
— From an ethical point of view, it is very difficult to argue that VLLW containing artificial radioactivity can be freely released.

The PNGMDR recalls also the possibility contained in the Public Health Code to authorize exceptionally the free release of materials after an exhaustive procedure. It is indicated by the Safety Authority that it is not planned to authorize such practices for a reuse in a public environment. Nevertheless, reuse in a nuclear environment after recycling may be authorized due to the fact that this management route does not cause problems of traceability. This strategy was used by AREVA in 2000 for lead reuse in the nuclear field. It consisted of a two step industrial process: a first decontamination step by melting in a decontamination facility located on the Marcoule site. The produced ingots, which had a bulk contamination less than 1 Bq/g, were sent to the D'Huart facility in Marseille, a conventional industry to fashion lead. The fashioned products were sent back for further reuse in the nuclear industry (mainly for biological protection in the facilities of EDF, CEA and AREVA).

4. THE DISMANTLING OF THE ENRICHMENT GASEOUS DIFFUSION PLANT GEORGES BESSE

In France, two categories of waste will be produced during decommissioning operations. The difference between the two categories is associated with waste zoning; this allows the places of waste production to be identified within the nuclear facilities, called 'areas'. These areas generate so-called 'nuclear' and 'conventional' waste.

The dismantling of the Georges Besse Eurodif gaseous diffusion plant will generate 160 000 tons of scrap metal waste divided into the two categories:

— 130 000 tons from process equipment made up of metallic materials of the same steel grade (E24 non-alloy steel, low-carbon 0.08 to 0.16%). These materials are slightly contaminated by uranium.
— 30 000 tonnes from nuclear facilities and materials of different grades (for example: aluminium, stainless steel, copper).

FIG. 1. Aerial view of Georges Besse Enrichment gaseous diffusion plant.

FIG. 2. A group of diffusers inside the plant.

Due to their radiological characteristics, packages of waste generated during decommissioning will be sent to an outside disposal facility ANDRA CSTFA (storage centre for very low level activity waste).

— With respect to its commitments to sustainable development, AREVA envisages an alternative to waste disposal at CSTFA. For mechanical process waste (130 000 tons), the solution advocated consists in melting metal parts to decontaminate them. In this approach it is aimed to decommission metal waste by a fusion process. The process dissociates, at the fusion point of metal, liquid steel from contamination. The contaminants are trapped in the form of uranium oxide UO_2 by slag. The slag is then dissociated from the steel. The molten steel is then poured into a geometry form compatible with later shaping processes. Slag containing most of the uranium contamination is collected separately and packaged as waste. Depending on the radioactive level, the slag disposal is to CSTFA or to CSF/MA (storage centre for low and intermediate short lived waste).
— The objective of fusion recycling is to obtain steel ingots with a residual radioactivity of about 1 Bq/g uranium. This target allows the re-introduction of steel into the public domain in some countries. However, as French regulations do not allow such a change of category, it is planned to increase the value of this steel by recycling to nuclear facilities.

The process envisaged, similar to the one implemented for lead recycling in Marcoule, aims to provide ingots to manufacturers so that they can develop parts for the nuclear industry. Manufactured products identified so far and likely to find an outlet in the nuclear industry are:

— Steel reinforcement bars for construction works;
— Plates for packaging waste for ANDRA disposal centres;
— Cauldrons for equipment for ANDRA disposal centres or nuclear parks.

In addition to steel re-use from Georges Besse plant dismantling, AREVA is studying the feasibility of developing similar processes for copper and aluminium waste from nuclear areas.

LEGISLATIVE AND REGULATORY CONTROL FOR THE SAFETY OF RADIOACTIVELY CONTAMINATED SCRAP METALS GENERATED FROM MINING AND MINERAL PROCESSING FACILITIES IN SOUTH AFRICA

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Abstract

In South Africa, enhanced levels of naturally occurring radioactive materials (NORM) are associated with many mining and industrial processes. Significant amounts of waste materials are involved which can result in radiation exposure of the workers and the public particularly through the diversion of materials into the public domain. The following operations have been regulated in South Africa for the past twenty years: operating metallurgical plants utilizing NORM, underground mining operations, scrap recyclers and smelters, and rehabilitation and remediation activities involving the above sites. The radioactively contaminated scrap metal generated from the above mentioned facilities is available for recycling in amounts of thousands of tons. The South African government has, to a certain extent, responded to the above-mentioned challenges by introducing regulatory controls to the affected industries. The existing regulatory controls have, however, not provided absolute answers to all issues associated with the management of scrap.

1. INTRODUCTION

Thousands of tons of scrap metal (iron and steel) are produced daily in South Africa. This scrap metal is mainly from the demolition of various facilities. As a result of the associated recycling, energy, landfill space and raw materials are conserved [1], this, in turn, contributes to sustainable development [2–4]. Many operations have been regulated in South Africa for the past twenty years, including: (a) operating metallurgical plants utilizing naturally occurring radioactive materials (NORM), (b) underground mining operations; (c) scrap recyclers and smelters and (d) rehabilitation and remediation activities involving the above sites. From these operations, radioactive material may be introduced into metal processing and cause contamination of the product if there is loss or lack of regulatory control; a result which metal producers wish strongly to avoid [5].

The Metal Recyclers Association (MRA) of South Africa consists of about 100 registered members and covers the collection and processing of almost 80% of all scrap in South Africa [3]. Currently many consumers demand certification that suppliers' products are free of radioactivity [6]. Most of the incidents involving contaminated scrap that end up in the suppliers' products lead to loss of money, business and put the consumers at risk [7].

Since 1983, more than 80 accidental melts have been reported worldwide involving radioactive material and this remains a major concern [8]. South Africa has had experience of this problem when one of its scrap processors supplied contaminated metal to the UK.

Vocilka [6] has reported on sources of radioactive scrap entering the metal processing industry. Sources of radioactive scrap can be: (a) human-made radioactive materials in devices such as medical equipment, gauges, radiographic cameras, and military aircraft instrumentation. Typically, they contain the radionuclides caesium-137, cobalt-60, irridium-192, radium-226 and americium-241; (b) NORM containing nuclides such as potassium-40, thorium-232 and uranium-253 that are encrusted in pipe fittings from oil and water industries; (c) alloyed metals and vintage scrap ferrous metal (not previously screened for radionuclides) containing cobalt-60 and thorium-232; (d) scrap from decommissioned nuclear facilities.

The aim of this paper is to give an overview of the South African situation in relation to radioactive scrap metals and to indicate the improvements in control which have occurred over the past two decades.

2. MATERIALS AND METHODS

Data gathered by the regulator authority, the National Nuclear Regulator (NNR), service providers and various scrap metal processors was used for the purpose of this study. The data was collated to present an overview of pre- and post-1994 periods.

3. DISCUSSION

The exploitation of a variety of ores (i.e. gold, phosphate, mineral sands etc.) and minerals containing elevated levels of naturally occurring radionuclides is one of the major economies of South Africa. Around 150 000 tonnes of uranium have been produced from gold and phosphate/copper ores since the 1940s, with South Africa being the fourth largest producer worldwide. During those years there were no controls over the movement of radioactive material. In

1990, regulatory requirements were introduced for the mining and minerals processing industry, particularly for the gold mining industry, but with the exception of controls on the movement of potentially contaminated scrap. As a result, radioactively contaminated material, handled unknowingly over a period of years, resulted in a number of sites becoming contaminated. In 1993, radioactive scrap was inadvertently exported from South Africa to the United Kingdom; it was returned because of the presence of contamination. This marked the beginning of tightened measures to control the movement of radioactive scrap within and outside the borders of the country. Requirements, for the regulation of radioactivity in scrap from the NORM and related industries, were formulated by the regulatory body and revised continuously over the years. This has led to most steelworks, foundries and major scrap recyclers being able to release most of the contaminated materials through approved procedures. However, problems can occur when the procedures are not adhered to and contamination spreads into the public domain. The graphical representation of current regulated operations in which NORM is being handled, including scrap, is shown below. It should be mentioned that before 1994 only 3 scrap dealers were under regulation; since then the number has grown to 22 scrap recyclers and 1 melting facility.

The enforcement of the use of 'drive through' monitors has emphasised the requirements. However, affordability has been also been a factor. Of all the scrap recyclers mentioned above, only six have radiation detection instruments at their

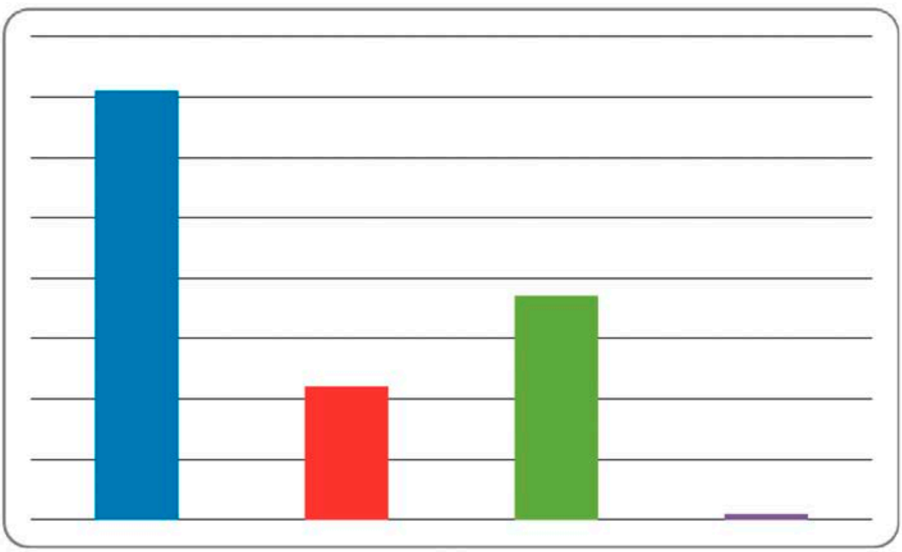

FIG. 1. Facilities currently regulated for mining and mineral processing facilities (MIMP).

gates; the others have only portable rate meters for dose and surface contamination measurement.

A large number of reports (i.e. roughly 2 incidents per month) are received of the alarms of detection devices being triggered. Incidents in which loads of scrap are rejected by steelworks which are not authorizedauthorized to use contaminated material are still occurring.

Incidents vary considerably, and while the majority of these relate to inadvertent movement of small amounts of radioactivity, there have been some instances of larger scale shipments of radioactively contaminated scrap crossing international boundaries.

The inadvertent movement of radioactively contaminated scrap and materials is of concern to the regulatory body which has responded to those concerns and recognises the need for response mechanisms to manage such activities.

Experience during the past 10 years has shown that source specific control of activities combined with regular inspections at the places of use have reduced the movement of NORM contaminated scrap from mining and mineral facilities.

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SYSTEM FOR PREVENTION, DETECTION AND RESPONSE TO RADIOACTIVE MATERIALS IN SCRAP METAL IN UKRAINE

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Abstract

The State control system to prevent, detect and respond to cases of radioactive material in scrap metal is functioning in Ukraine. The system includes regulations for the safe and secure management of metal scrap and administrative and technical measures to prevent, detect and respond to cases of radioactive material in scrap metal. The key elements of prevention are the system of licensing and supervision in the sphere of radioactive material use and the State system for inventory, registration and control of radiation sources. Metal scrap management is licensed by the Ministry of Industrial Policy and one of the licence conditions is radiation control of the scrap metal. State supervision of the operations with metal scrap is provided by Ministry of Health and Ministry of Environmental Protection according to the regulation ‘State sanitary-ecological standard for metal scrap management’. Specific standards exist for the export of metal scrap. Export consignments are followed by a certificate that proves the radiological safety of the metal. Ukrainian metallurgical plants provide an input radiation control of metal scrap and an output control of the produced metal. Thus, there exists a five barrier system of metal scrap control: border control; exclusion zone perimeter control; metal scrap dealers control; metallurgical plants (input control and output control of produced metal); and export consignments radiological certification. To regain control over orphan sources (including occasional radioactive material in the scrap metal) the ‘procedure for interaction of executive authorities and involved legal entities in case of revealing of radiation sources in no legal use’ was approved by a Resolution of the Cabinet of Ministers of Ukraine. The investigation of each case with feedback, information of involved bodies, safe and secure storage of restored radioactive material are provided according to this procedure.

1. INTRODUCTION

A comprehensive programme of measures exists in Ukraine to prevent, detect and respond to cases of radioactive material in scrap metal.

These measures include:

— Prevention (physical protection; inventory and control, export-import control);
— Detection (passive and active physical search for radioactive material);

— Response (emergency response, investigation, law enforcement, information exchange, corrective actions).

2. PREVENTION

The key element of prevention of radioactive material in scrap metal is the State regulatory system that includes:

— State system of licensing and supervision in the sphere of radioactive material use;
— State system for inventory, registration and control of radiation sources (the State Register);
— State programmes for gaining and regaining control over vulnerable and orphan radioactive sources.

The main goal of the prevention system is to trace every radioactive source from 'cradle to grave' and to ensure secure protection of radioactive sources in order to prevent unauthorized access, damage, loss, theft, unauthorized transfer, and malicious use. The ideal situation is that every source is in a controlled and authorized place from the moment of import (production) till export (disposal) and is secured at this authorized place. This ideal situation can be approached through strengthening the regulatory system and by regaining control over existing orphan sources to the maximum extent possible.

Ukrainian legislation for the safety and security of radioactive sources places the prime responsibility for safety and security on the person who is granted the relevant authorization. There are 3804 users of radioactive sources in Ukraine (2837 medical use and 967 non-medical).

The State regulatory system includes: establishment of regulatory requirements, permissive activity, inspections and enforcement. Permissive activity includes registration in the State Register of Ionizing Radiation Sources and licensing of the radioactive sources that are not exempted from regulatory control.

The State Nuclear Regulatory Committee of Ukraine (SNRCU) is the Ukrainian regulatory authority that is competent, in particular, for radioactive sources safety and security regulation. SNRCU is responsible for the coordination of all executive authorities and institutions of local governments that have competence in radiation safety and radiation protection.

2.1. Security

Compliance with security requirements is a necessary condition for issuing of any authorization. From the point of view of security, sources are divided into 2 categories. The first category radioactive sources (activity more than 3.7×10^{13} Bq and half-life more than 5 years) require management in the protected area, which is surrounded by a physical barrier (protected area is in the controlled area, which is surrounded by a perimeter, which is guarded).

From the security point of view, in order to obtain a licence, the applicant must have available: a security assessment in a safety analysis report and implemented physical protection measures for radioactive sources according to the radioactive source category; an accounting system with yearly inventories and registration in the State Register; a managment and personnel trustworthiness check; a system of security administrative measures including information security and allocation of security responsibilities; emergency plan and suitable material resources and trained response personnel; financial capabilities to reimburse the cost for management of disused sources and damages in case of a radiation accident. One of the obligatory parts of emergency plans is the prompt reporting to the regulatory body and other relevant authorities about decontrolled, lost, stolen or missing radioactive sources. The security of the applicant's facility is examined before the issue of a licence and by planned inspections.

2.2. Accounting and control

Registration of radioactive sources is obligatory for all sources that are under regulatory control. The registration procedure is established in the regulation 'Ionizing Radiation Sources State Registration Procedure'. The State Register of Ionizing Radiation Sources (Register) is a unified tracing system for registration, accounting and control of radiation sources. The State Register for Ionizing Radiation Sources was commissioned on March 292007. The Register contains data on all radiation sources in electronic form and traces radioactive sources starting from the moment of their appearance on the territory of Ukraine and until their removal from Ukraine or transfer to a special enterprise for radioactive waste management (disposal). There is a continous interaction between the Register and the State Custom Service of Ukraine, the State Export Control Service of Ukraine and the Radioactive Waste Register. Upon the request of the regulatory authorities and State authorities involved in the handling of radiation sources, the Register provides information on radioactive sources. The Register is responsible for the search of information about lost and found radioactive sources. The Register provides an annual report to the regulatory bodies. At the end of 2008, 3918 radioactive sources and 10979 radiation generators were registered and controlled.

2.3. Specific measures for vulnerable sources

From the point of view of their appearance in metal scrap, two groups of sources are considered as vulnerable — spent radioactive sources and orphan sources. A special programme of preventive measures exists for both groups.

For the security of disused radioactive sources — only the following methods of management are allowed:

- Temporary secured storage at the facility (not more than 6 months);
- Return of radioactive sources to the country of production according to the agreement with supplier;
- Transfer of radioactive sources to special enterprises for radioactive waste management and disposal.

For more than 1000 highly active spent sources, compliance with these rules is not achieved. These sources are legacy sources from the former Soviet Union and are stored in shutdown facilities. According to international experience, such sources can give rise to accidents possibly via metal scrap following melting or contamination, for example, such accidents as occurred in Juarez, Mexico and Goiania, Brazil. To prevent accidents, the Ukrainian Government has approved the State Programme For Ensuring Safe and Secure Storage of Spent Highly Active Ionizing Radiation Sources. The main task of the programme is to create infrastructure for storage of highly active spent sources in specialized storage facilities and fulfill all the operations necessary for the safe transfer of the sources to these storage facilities, in particular to provide: engineering and radiation surveys of facilities and a survey of the physical condition of spent sources in the facility; the development of techniques for removal and containerization and the transportation of sources to the places of their temporary storage at the specialized radioactive waste management facilities. The programme is now being implemented.

A special campaign is now under development for users of spent radioactive sources that are bankrupt or insolvent. In 2009, spent sources from these users will be taken to the specialized enterprise for radioactive waste storage at the expense of the State Budget.

To make spent sources less vulnerable, a regulation is being prepared according to which the cost of transfer of spent sources to the specialized enterprise for radioactive waste storage will be paid from Radioactive Waste Management Fund. The user shall pay to the Fund in advance, when buying the new source.

A passive physical search for orphan sources is being implemented in Ukraine. Administrative searches and active physical searches for orphan sources are being implemented through: State Inspections on Nuclear and Radiation Safety of the State Nuclear Regulatory Committee of Ukraine and local State Sanitary Epidemiological Services of the Health Ministry of Ukraine. A programme for orphan sources searching is now being discussed with competent state authorities.

Inspectors of State Inspections on Nuclear and Radiation Safety are trained for the search of radioactive sources using international assistance. Two training events were organized with the support of German Regulatory Authority (BMU/GRS) and the US Department of Energy (Argonne National Laboratory). The USA provided 10 sets of radiometers for search and identification of radioactive sources.

In the framework of international cooperation, several projects to enhance the physical protection of priority sites have been implemented:

— For 46 oncology clinics (IRTR - USA initiative for threat reduction);
— For research institutions (MPC@A - USA Material Protection, Control @ Accounting Programme).

The USA continues its assistance to enhance physical protection for other sites with highly active radioactive sources.

2.4. Decommissioning

A specific clearance procedure is followed during the decommissioning of radiation and nuclear facilities.

2.5. Dissemination of information on radioactive material in metal scrap

Since 1997, Ukraine has been participating actively in the IAEA programme on accumulation and exchange of information about illicit trafficking incidents involving nuclear and other radioactive material. Information on radioactive material in metal scrap is regularly sent to the IAEA DatabaseDatabasedatabasebase office on illicit trafficking. This is done by SNRCU in accordance with the par.16 of the national ‘Procedure on cooperation of the executive state authorities and legal persons which conduct practices in the sphere of use of nuclear energy in case of revealing of ionizing radiation sources in illicit trafficking’.

3. DETECTION OF CASES WITH RADIOACTIVE MATERIAL IN SCRAP METAL

3.1. Radiation monitoring at the borders

Not all border cross points are equipped with portal monitors. A special programme for the improvement of radiation monitoring at the border is being implemented by the State Border Administration.

3.2. Radiation monitoring at the border of Exclusion Zone

The Exclusion Zone is a territory around the Chernobyl Nuclear Power Plant that was contaminated after the Chernobyl accident in 1986 and where no population and no activities are allowed except activities aimed at radiation and ecological safety. The Exclusion Zone has a guarded perimeter. Only cleared material with radiation certificates is transported out of the Zone. This material is additionally monitored at Zone perimeter cross points.

3.3. Activities with metal scrap

Activities involving scrap metal are licensed by the Ministry of Industrial Policy. The licence is granted if the licensee complies with the licensing conditions. At present there are 2400 licensed scrap dealers. License conditions include availability of radiation control of the scrap by trained personnel according to the established regulation for metal scrap management radiation safety. Radiation control includes: input and output radiation control, periodic control of the site and storage facilities. Regulations for metal scrap management radiation safety are obligatory and, if violated, the licence can be withdrawn. All consignments of metal scrap are followed by the issuance of the relevant radiological certificate. The conditions of the certificate issuance are given in the Table 1.

Strict compliance with the requirements for metal scrap radiation control should ensure that no scrap with radioactive material arrives at metallurgical facilities, but in real life the system is not perfect. Some radioactive materials slip through the monitoring system at metal scrapyards and are detected during input control at metallurgical facilities that are equipped with portal monitors. The number of such cases in Ukraine is given in Table 2. During 2004–2008 the most contaminated lot had a radiation dose rate of 3000 mcR/hour on the surface.

State supervision of operations with metal scrap is provided by the Ministry of Industrial Policy, the Ministry of Health and the Ministry of Environmental Protection. For example, in 2008 there were 16 prescriptions for metal scrap

TABLE 1. CONDITION OF METAL SCRAP CONSIGNMENT CERTIFICATE

It is allowed to use metal scrap:	Action levels		
	Dose rate, 1m from the surface, mcGy/hour	Not removable contamination, particles/minute sq cm	Removable contamination
Without any limitations (including export)	< 0.26	< 30	No
On the territory of Ukraine	< 0.43	< 100	No
Not allowed to use	≥ 0.43	≥ 100	Yes

TABLE 2. NUMBER OF INCIDENTS INVOLVING RADIOACTIVE MATERIAL IN SCRAP METAL

Radioactive material	2004	2005	2006	2007	2008
Metal scrap contaminated with NORM	18	23	14	15	11
Radioactive source in metal scrap	2	—	—	5	1

dealers to eliminate violations and 2 licenses were withdrawn. These facts are evidence that the radiation monitoring provided by metal scrap dealers needs to be improved. The SNRCU together with the Ministry of Industrial Policy decided that the main areas for improvement should be:

- — training of the staff;
- — financial arrangements that will release dealers from the financial burden of management of radioactive material when it is detected;
- — metrological supervision of the scrap dealer's radiation monitoring systems;
- — revision of 'Licensing conditions for the activities of stocking up, processing, metallurgical processing of metal scrap of ferrous and nonferrous metal';
- — equipping all metallurgical plants with input/output portal monitoring systems;
- — working out a national strategy according to the UNECE 2006 Recommendations on Monitoring and Response Procedures for Radioactive Scrap Metal (http://www.unece.org/trans/radiation/radiation.html).

To improve the training of personnel involved with metal scrap that can occasionally include radioactive material, the SNRCU prepared a reference booklet about the radioactive material that can be found in metal scrap. This booklet includes pictures and supplementary information that is important from the safety point of view. The booklet has been disseminated in electronic form for the use of scrap dealers and metallurgical facilities.

A specific and stringent standard exists for the export of metal scrap. Export consignments are followed by a certificate that proves the radiological safety of the metal scrap.

Ukrainian metallurgical plants are required to provide input radiation control of metal scrap and output control of produced metal. A specific standard for the control of produced metal has been prepared. Ukrainian legislation includes a requirement to provide input radiation monitoring at metallurgical plants, but does not require the installation of specific monitoring equipment with specific characteristics. For this reason, the SNRCU is encouraging metallurgical plants to install and operate portal monitors for input control.

Thus, there exists a multi-barrier system of metal scrap control:

— Border and Exclusion Zone perimeter control;
— Metal scrap dealers (input and output control, periodical control of site and storage facilities);
— Metallurgical plants (input control and output control of produced metal);
— Radiological certification of export consignments.

4. GAINING AND REGAINING CONTROL OVER ORPHAN SOURCES

To facilitate regaining control over orphan radiation sources the ‘procedure for interaction of executive authorities and involved legal entities in case of revealing of radiation sources in illegal use’ was approved by the Cabinet of Ministers of Ukraine. This procedure has existed since 1997 and is currently under review. The procedure provides measures to regain control over sources. The measures are shown in Table 3.

4.1. Securing the sources

Intervention when radioactive material is found in metal scrap is performed by local authorities of the Ministry for Emergencies of Ukraine and specialized enterprises of State Corporation ‘Ukrainian Association Radon’ (‘Radon’) which is subordinated to the Ministry. ‘Radon’ has six specialized enterprises for radioactive waste management which include: specially trained emergency

TABLE 3. PROCEDURE TO REGAIN CONTROL OVER ORPHAN RADIOACTIVE SOURCES

Action	Responsible authority or person
Detection - inform local executive authorities or internal affairs bodies	Legal or physical person who has detected a suspicious material
Material security measures arrangement at the site and information of local radiological offices of State sanitary epidemiological supervision service	Local executive authorities or law enforcement agencies
Preliminary examination of a suspicious material, inform local executive authorities as well as territory authorities of Ministry of Emergencies of Ukraine, internal affairs bodies about necessary individual protection measures	State sanitary epidemiological supervision service (Ministry of Health)
Criminal proceedings and conduction of investigation	Law enforcement authorities
Nuclear forensics (if needed)	Institute for Nuclear Research
A source shall be: taken away by emergency team, placed at special enterprise for radioactive waste management, stored until an owner is found or criminal case is closed.	Enterprises for radioactive waste management ‘Radon’ emergency teams (Ministry for Emergencies)
Search for owner: search through the State Register of Radiation Sources, informing the IAEA, competent authorities of interested countries and mass media.	State Nuclear Regulatory Committee of Ukraine, Register
Financing	Local authorities (with reimbursement of the owner if found)

personnel, necessary devices and equipment, including radiometric and dosimetric devices for assessing the radiation situation at the sites of accidents, equipment for individual protection and decontamination, mobile communication facilities, transport and packing containers.

Until now, incidents involving radioactive material in metal scrap have not involved contamination of industrial sites, facilities and environment, but there were two incidents with response actions similar to the case of radiation source melting.

The first one occurred in 2008 at the big metallurgical plant ‘Azovstal’, where part of the moisture measuring gauge containing an Am-Be source was melted. About 3000 tons of contaminated metal was produced with an average activity of 14 Bq/kg. This material was cleared with the condition that it is only used at an industrial site.

The second one was detected in 2007 at a landfill, where a spot was found, contaminated with caesium-137 probably as a result of a non-authorized release of material that was subsequently melted. The site is being decontaminated at the present time. About 100 tons of radioactive waste with activity in the range 10^5 to 10^7 Bq/kg will be stored at the specialized waste enterprise. Careful checking of all users of caesium-137 sources and melting facilities demonstrated that all sources are in place and that facilities are not contaminated. It was concluded that the problem was due to old (historical) contamination.

5. CONCLUSION

The system to prevent, detect and respond to cases of radioactive material in scrap metal in Ukraine is based on the State regulation of activities with radiation sources and the State regulation of activities with metal scrap and metal production. This system is prescriptive and thus requires sufficient state resources for supervision and enforcement. The international assistance provided for the searching and securing of radioactive sources and material has been helpful to Ukraine.

COMPLIANCE WITH RADIOLOGICAL CRITERIA: MONITORING, CHARACTERIZATION AND GOOD OPERATIONAL PRACTICES

(Session 3)

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SUMMARY OF SESSION 3

COMPLIANCE WITH RADIOLOGICAL CRITERIA: MONITORING, CHARACTERIZATION AND GOOD OPERATIONAL PRACTICES

In this session, criteria relevant to the release of metals from nuclear regulatory control were presented and methods for complying with the criteria and for detecting radioactive materials in scrap metal were discussed.

It was argued that, over time, radionuclides will inevitably find their way into commodities, that the issue is global and that internationally acceptable criteria are therefore necessary to allow international trade. An intergovernmental consensus on levels at which materials can be released from regulatory control (clearance levels) exists — as set out in IAEA Safety Standards Series RS-G-1.7 (2004). However, the existing scheme is complex and for global application it should be simplified.

The need for the monitoring and control of the radioactive materials in scrap metal at the borders of countries as well as at the entrance to scrapyards and metal factories was stressed in several presentations. In this context, the ongoing efforts of the USA, in the context of the safety and security of radioactive materials, to install radiation monitoring systems at more than 100 major entry points (Megaports) worldwide were described. It was noted that when radioactive materials are detected at the Megaports the local regulatory response arrangements differ substantially from country to country and it would be desirable for a more globally unified response approach to be developed.

In a presentation discussing the sensitivity of scrap metal monitoring systems, and specifically portal or gate monitors, it was noted that the detection of radioactive material depends on the energy of the radiation source, its position in the load and the density of the metal scrap. Significant radiation sources can be 'hidden' in loads by being shielded by surrounding metal and thereby escape detection. In most cases the triggering of an alarm at a portal monitor is sufficient for a scrap metal facility or metal factory to reject a load. An important finding is that for ^{60}Co uniformly distributed in a load at the international clearance level, typical portal alarm monitors will not be triggered.

A basic problem in managing the problem of radioactive material in scrap metal is that the workforce of scrap metal yards, metal factories and those responsible at borders are unfamiliar with radiation and on how to work safely with it. Several papers stressed the need for training of the personnel who are most likely to encounter the problem of scrap metal containing radioactive material.

In the panel session after the presentations the following points were made:

The subject matter of the conference can be seen as being comprised of short term issues, that is, the prevention, detection and response to radioactive material entering scrap metal where the source is mainly NORM and orphan sources, and longer term issues concerned with the eventual inevitable presence of low levels of radionuclides in the steel pool. For this it will be necessary for an understanding to be reached between the nuclear and steel industries. To facilitate this it was proposed that an international forum be established which the two sides could exchange concerns and ideas for their solution.

It was noted that there are already some international instruments in existence that could be used to address some of the issues raised at this conference. The international Regulations on the Safe Transport of Radioactive Material were cited as one example.

The existing international clearance criteria are expressed in terms of activity concentration in materials. For the purposes of practical application in detection systems, the criteria need to be in terms of the quantities that are measured, that is, gamma radiation dose rates in excess of natural background. Guidance on this aspect would be useful — recognizing that the actual numbers will tend to be equipment and location specific.

CONTROLLING THE OUTCOME OF MELTING RADIOACTIVE SOURCES IN SCRAP METAL: FROM EXCLUSION, EXEMPTION AND CLEARANCE TOWARDS A ‘CODEX METALLARIUS’

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Abstract

Orphan radiation sources have been inadvertently incorporated into scrap metal and traces of radioactive residues have appeared in finished metal products causing public anxiety, despair in industry and governmental concern. The international principles of exclusion, exemption and clearance can be used to tackle this problem. They are described in detail, as they are becoming universally established for defining the scope of radiation protection regulations. However, notwithstanding the relevance of these principles, the paper suggests a straightforward professional consensus for discontinuing radiological control of commodities with minute traces of radioactive residues. The consensus should unambiguously specify a generic activity concentration in inedible commodities, including metals, below which radiological control may be effectively relinquished. A subsequent legally binding intergovernmental undertaking could resolve the current regulatory ambiguity, facilitate commercial exchange and ensure adequate public protection. For metals, it might take the form of a ‘Codex Metallarius’ (similar to the existing Codex Alimentarius for edible commodities) establishing a generic level of radiological acceptability for finished metal products. Furthermore, it is proposed that there should be an international convention to prevent radioactive sources becoming orphaned from regulatory control and then inadvertently appearing in trash and scrap.

1. INTRODUCTION

1.1. Aim

The International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal (the Conference) may become a cornerstone for the resolution of one of the more elusive problems of radiation protection: the radiological control of metals containing adventitious radioactive substances. Steel mills and foundries in many countries have melted metal scrap containing radioactive sources that were ‘orphaned’ from regulatory control. ‘Contaminated’ products, such as rebar and cast iron furniture, have been distributed all over the world creating public anxiety, despair in industry and governmental concern. This paper is aimed at discussing how to deal with the radiological outcome of these events, namely decontaminating the installations (and in some case the surrounding environment), and controlling the metal products that may contain radioactive residues from the melting. The paper will concentrate in the last issue although most of its considerations can also be applied to the rehabilitation of the affected mills and foundries. Moreover, the paper deliberations may also be applicable to other inedible commodities in public use.

1.2. Content

The paper describes the well established international principles of exclusion, exemption and clearance from control, which are becoming universally used for defining the scope of radiation protection regulations. These principles are established in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS)[1]. The BSS encompass the safety requirements adopted by all relevant organizations within the United Nations system and are used by most national regulators. They are based on the 1996 recommendations of the International Commission on Radiological Protection (ICRP) [2] — a non-governmental academic charity founded in 1928 that provides guidance for radiation protection standards worldwide.

This paper explores the historical evolution of the relevant concepts for defining the scope of regulatory control, both those recommended by the ICRP, including the latest relevant ICRP recommendations [3–4], and those established in the BSS. However, the paper's ultimate objective is to encourage a clear and unambiguous international intergovernmental agreement that specifies a generic level of radioactivity concentration in inedible commodities, particularly metals, below which no radiological control is required. Whether this is achieved through exclusion, exemption or clearance or by using any other *ad hoc* mechanism is not central to the issue. What is urgently needed is a global accord that definitively resolves the current international ambiguity in the regulatory treatment of radioactive residues in commodities, in general, and metals in particular. This should facilitate commerce and commercial exchange while still protecting adequately public health and safety.

1.3. Premises

The paper is based on two premises that can be perceived as conflictive but that are in fact complementary, namely:

- In order to prevent inadvertent disposal of ‘orphaned’ sources in scrap metal, regulatory control over significant radiation sources should not be relinquished under any circumstance;
- Below certain levels of residual radioactivity, metal products do not require regulatory control.

The paper deals mainly with the second of these premises, but under the precondition of the first. It is underlined (and emphasized) that adequately controlling radiation sources and preventing them from becoming orphaned from regulatory control is a prerequisite, a condition for solving the problems created by the existence in metals of traces of inadvertently melted radioactive residues. Limiting the unintended presence of radioactive sources in scrap metal prevents the regulatory problems created by the radioactive contaminants in finished metals. For two decades, proposals have been made for a global legally binding undertaking that establishes clear obligations on States to keep control over radiation sources (and penalties to those that fail to do it properly) as the only effective solution to the ‘orphan’ source problem [5–11]. The author remains in support of this proposal and, furthermore, believes that there should now be an ‘international convention on the control of radioactive sources’.

2. DESCRIBING THE PROBLEM

The problem created by the inadvertent melting of radioactive sources in scrap is a serious one. It is surprising that Governments have failed to tackle it after the many warnings from the professional community. More than a decade ago, starting at the Dijon 1998 International Conference on Safety of Radiation Sources and Security of Radioactive Materials, many seminal papers, e.g. [12–14], and a full review by the US National Council on Radiation Protection and Measurements (NCRP) [15], warned about the seriousness of the situation. The Dijon Conference already suggested that an international convention was desirable [16, 17]. It was a reaction to dramatic experiences with melted orphan sources. They included the export of large amounts of contaminated metal products (Ciudad Juarez, Mexico [18–21]), a large public consequence situation (Taiwan [22, 23]), and a substantial economical and social impact situation (Algeciras, Spain [24]). In sum, too many incidents have occurred and continue to occur. Some were reported in the open scientific literature, mainly by the IAEA [25–34]; others by the media (the radioactive scrap metal brochure of the Nuclear Free Local Authorities; an antinuclear British NGO [35] provides a rather comprehensive reference to some cases). From this copious literature it can be seen that the activities of the melted sources have ranged from tiny amounts to large sources of up to several tens of TBq, and the activity concentrations in the finished products have ranged from minute fractions of Bq/g to levels of several KBq/g.

Members of the public have become anxious about a phenomenon they cannot understand, or quantify properly, and which worries them because of possible health implications. The industry is in despair and has reacted irrationally to the problem, demanding a technically unattainable zero content of radioactive substances in metal products. Its concerns are both market rejection considerations due to the public health perception issue and the huge economic penalties associated with the decontamination of process facilities. The fact that the ultimate radioactive content in the finished products may just be traces of radioactivity seems to be irrelevant for both the general public and also for the industry: the 'bottom line' is the existence of radioactive substances in the produce (however small) and not how much radioactivity it contains.

In spite of this dramatic history, the governmental reaction to professional, public and industry demands has been at one extreme, timid and at the other, irresponsible. In spite of all the claims for a international convention to prevent the control of sources being relinquished, governments have only been able to agree on a 'Code of Conduct' on the safety and security of sources [36]; namely on a voluntary non-binding document that does not contain any penalty for those governments that do not exercise their responsibilities in source control. In relation to one aspect of the problem, i.e., the control of commodities containing traces of radioactive residues, governments were able to agree on criteria for exclusion, exemption and clearance and on a wide and complicated range of values for relinquishing control, but again there is no legally binding undertaking.

The radiation protection profession has not been very helpful either. While clear recommendations have been issued on exclusion, exemption and clearance, a very much needed simple authoritative declaration on the issue was never promulgated. It could have been simply formulated, e.g. as follows: uncontrolled orphan radioactive sources represent a serious public health issue that must be solved by Governments, but metallic products containing traces of melted sources are not necessarily a public health challenge.

3. HISTORICAL EVOLUTION

3.1. Ancient rationale for controlling trivia

The problem being faced is the control of trivial amounts of inadvertent radioactive residues in metals and it is worthwhile to explore some historical experience on this issue. Since ancient times, societies have tried to avoid that public officials distract themselves in controlling trivia. Two *ad hoc* early legal principles were an essential part of the Roman law for this purpose (Perhaps they were applied two millennia ago in the city hosting the Conference: Tarragona which at the time was termed *Tarrago*!). These principles are termed '*de minimis non curat lex*' (namely 'the law shall not concern itself with minutia') and '*de minimis non curat prætor*' (namely, '[if minutia is legislated] the praetor or regulator could still be unconcerned with minutia [and deregulate it]). The first principle addresses situations that need not be covered by the relevant legislation; the second addresses the situations, among those covered by the law, which can be freed by the regulator from some or all regulatory controls. The obvious aim of these principles were not only legal rationality but also preventing the authorities from having to waste public resources controlling trifles — as these resources could be more efficiently used for controlling important issues. At least in the western societies and since those ancient times, these principles have implicitly governed the legal problem of deregulating what is inconsequential, unfeasible, unimportant, or irrelevant to control. The principles are commonly used (sometimes implicitly) in familiar regulatory situations, such as municipal decisions that affect daily life — for instance, controlling cars but not bicycles, or regulating human dwellings but not coatings for pets.

3.2. Misunderstanding the early logic

Radiation control practices, however, eluded the usage of these simple straightforward principles — at least until recently. Moreover, a serious grammatical mistake was introduced in some radiation protection legislation. The expressions *de minimis non curat lex* and *de minimis non curat prætor,* which are both *ablative* grammatical cases, i.e. denoting *cause*, were converted into a single simplified expression in which *de minimis* was converted into an adjective qualifying a quantity, for instance, the quantity radiation dose;for instance [37–40]. This mistake created a confusion that still permeates into discussions on regulatory scope. It equated *lex* and *prætor*, i.e. *law* (*legislator*) and *judge (regulator*). Unsurprisingly, it implicitly changed the focus of deregulation from *cause* to *quantity.*

3.3. Contemporary regulatory vacillations

Half a century ago, the IAEA issued one of the first international regulatory instruments, the 1967 edition of IAEA Safety Series 9, (the first BSS). At that time, the experts drafting the standards seemed to be convinced that some kind of exclusion/exemption should be used for defining its scope. The 1967 BSS was limited to operations with radioactive substances at concentrations exceeding 0.002 μCi/g (74 Bq/g) or solid natural radioactive substances at concentrations exceeding 0.01 µCi/g (370 Bq/g) [41]. However, this practical rationality was lost in the 1980s when a kind of idealistic purism penetrated the international regulatory framework. Thus, the 1982 edition of the BSS implicitly required that any amount of radioactive substance, however small, should be regulated [42]. The practical problems created by the decision to regulate everything was ultimately addressed in 1988 by the IAEA and the Nuclear Energy Agency of the OECD when the 'Principles for the Exemption of Radiation Sources and Practices from Regulatory Control' [43] were issued, which re-introduced the limitation of the scope of regulatory standards.

3.4. Regulatory enlightenment

In 1990, the ICRP issued its general recommendations as ICRP Publication 60 [2]. ICRP advised that "sources that are essentially uncontrollable…can best be dealt with by the process of exclusion from the scope of the regulatory instruments" (§ 291). ICRP Publication 60 also recognized that a concept of exemption had been in international use for some years, and recommended that…" In order to avoid excessive regulatory procedures, most regulatory systems include provisions for granting exemptions…The Commission believes that the exemption of sources is an important component of the regulatory functions…There are two grounds for exempting a source or an environmental situation from regulatory control. One is that the source gives rise to small individual doses and small collective doses. The other is that no reasonable control procedures can achieve significant reductions in individual and collective doses. The basis for exemption on the grounds of trivial dose is much sought after, but very difficult to establish. Apart from the difficulty of deciding when an individual or a collective dose is small enough to be disregarded for regulatory purposes, there is a considerable difficulty in defining the source. . . The underlying problem is that exemption is necessarily a source-related process, while the triviality of the dose is primarily individual-related." The Commission also indicated that "the second basis for exemption calls for a study similar to that needed in the optimization of protection. It provides a logical basis for exemption of sources that cannot be exempted solely on the grounds of trivial doses, but for which regulation on any reasonable scale will produce little or no improvement". Thus, by the end of the century, international standards had followed these recommendations and regulatory rationality had returned to the international scene. The 1996 edition of the BSS [1] introduced the concepts of 'exclusion' and 'exemption' as modern synonyms of *de minimis non curat lex* and *de minimis non curat prætor*:, respectively. These principles have been maturing for over one decade [44] and since the end of the century have become the basis for defining the regulatory scope of radiation protection.

3.5. Defining the regulatory scope

Exclusion

The 1996 BSS established that any exposure whose magnitude or likelihood is essentially unamenable to control through the BSS requirements should be deemed to be excluded from the standards [1] (Article 1.4). According to this approach, exposures that may be excluded from radiological protection legislation include uncontrollable exposures and exposures that are essentially not amenable to control regardless of their magnitude.

Exemption

Importantly, the 1996 BSS definitively establishes that certain activities may be exempted from regulatory requirements when the application of such requirements is not warranted. The BSS states that practices and sources within practices may be exempted from the requirements of the standards provided that they comply with exemption principles or with exemption levels defined on the basis of those exemption principles. They also state that exemption should not be granted to permit practices that would otherwise not be justified [1] (§ 2.17 and 2.18).

Exemption principles

The exemption principles adopted internationally can be summarized as follows [1] [43]: (a) the expected individual risks that may be attributable to the exempted situations must be sufficiently low as not to warrant regulatory concern; and (b) radiological protection must be optimized, taking into account *inter alia* the societal efforts that are required to regulate. Thus, a person responsible for a radiation exposure situation may be exempted from radiological protection requirements if the individual risk attributable to the situation is judged to be very small, and the consequent detriment is irrelevant in relation to the commitment of resources implied by the protection to be achieved through the application of the requirements. Additional principles are that the activities creating the exposure situation must be justifiable and the radiation sources must be inherently safe.

Exemption Levels

These principles were applied by intergovernmental organizations and by national regulators to derive radionuclide-specific international ‘exemption levels' that have been used generically and universally for deciding whether or not to exclude specific planned exposure situations. Principles and methods for deriving exemption levels were first issued by the European Commission [45] and subsequently derived exemption levels were established in the BSS [1] (Schedule I). The values in the BSS were also used in the European Directives [46]. The defined scenarios assumed small-scale usage of radionuclides; situations involving large volumes of radioactive materials with very low activity concentrations were not explicitly addressed.

Clearance

While the concept of exemption determines *a priori* whether to regulate a specific exposure situation, conceivably, the concept could also be used *a posteriori*, i.e. exemption could also be considered for situations already subjected to regulatory requirements and which do not warrant continued regulation. The term 'clearance' has been used internationally to describe such a process of *a posteriori* exemption. Thus, clearance was defined in international standards as: 'removal of radioactive materials or radioactive objects within authorized practices from any further control by the national authority' [1] (Glossary). Clearance is therefore a special case of exemption, not an entirely different concept; it is, in fact, a subcategory of exemption. Unfortunately, however, the English word does not help to convey the idea of '*a posteriori*' exemption from regulatory obligations already undertaken. Clearance has many different meanings in English, which are completely unrelated to the concept of exemption, and it is not directly translatable into other languages (e.g. in international documents, it was translated as '*libération*' (liberation) in French and as '*dispensa*' (dispensation) in Spanish). Not surprisingly, there were different interpretations of the concept, which resulted in some confusion in its usage. In contrast to exemption, clearance is specifically defined as applying to radioactive materials. Cleared radioactive materials are released from any prior form of regulatory control, or, more accurately, regulatory controls no longer apply to the person previously responsible for them. Clearance can be seen, therefore, as a process of relinquishing regulatory control.

Clearance levels

The original incompleteness in the international derivation of exemption levels was corrected with the international safety guide on the 'Application of the Concepts of Exclusion, Exemption and Clearance' [47], issued in 2004, which provides exemption levels of activity concentration in bulk amounts of radioactive materials. (These were established in the Resolution GC(48)/RES/10 of the IAEA General Conference adopted in September 2004 by more than 140 IAEA Member States [48]).

Clearance during transport

Cleared materials have to be transported. Therefore, similar assessments were made for radioactive materials in transport, and *ad-hoc* exemption levels were established in the international ‘Regulations for the Safe Transport of Radioactive Materials’ (the Transport Regulations) [49].

Clearance in affected environments

There are not specific international recommendations or standards for remediating affected environments around steel mills and foundries where melting of metal scrap containing radioactive sources have occurred and radioactive materials were released into the environment. However, the basic principles of clearance can be used. If long lived radionuclides are involved, a situation of prolonged exposure could appear. ICRP has issued specific recommendations for dealing with this type of situation [50]. In addition, the IAEA has issued a number of technical publications on restoration of contaminated environments that can be used in these situations [51–54]. A recent review on the subject is being published [55]. In any case, non-technical factors will impact on the decision making processes in environmental remediation [56].

Controlling edible commodities

In parallel to these intergovernmental agreements aimed at the application of exclusion, exemption and clearance in inedible commodities, similar intergovernmental concurrence has been reached for foodstuffs and drinking water. It is interesting to recapitulate the evolution of these agreements in order to obtain some perspective on the radioactivity concentrations to be controlled in edible in relation to inedible commodities. In 1989, the Codex Alimentarius Commission (CAC) had adopted guideline levels for radionuclides in food following accidental nuclear contamination for use in international trade [57]. The Codex levels, which are applicable for six radionuclides – namely ^{90}Sr, ^{131}I, ^{137}Cs, ^{134}Cs, ^{239}Pu, and ^{241}Am, were adopted in the BSS [1] (§ V-10). Long term exposures presume a mixing of contaminated foodstuffs with uncontaminated materials, which will result in a lower annual exposure in subsequent years. In recent years, CAC considered broadening the scope of the Codex levels [58], and referred the issue to the Codex Committee on Food Additives and Contaminants (CCFAC) for consideration [59–63]. Eventually, CCFAC forwarded revised levels to CAC, which were adopted as final Codex levels [64] and issued by CAC [65]. Separately, the World Health Organization (WHO) developed specific guidance levels for radionuclides in drinking water, which have been incorporated into the third edition of the WHO's Guidelines for Drinking Water Quality [66].

4. RECENT DEVELOPMENTS

4.1. New ICRP general recommendations

Following the intergovernmental developments described above, the ICRP issued new recommendations as ICRP Publication 103 in March 2007 [3]. While ICRP continues to recommend that its system of radiological protection applies to all exposures to ionizing radiation from any source, regardless of its size and origin, it clarifies that its recommendations can only apply in their entirety to situations in which either the source of exposure or the pathways leading to the doses received by individuals can be controlled by some reasonable means — where 'reasonable' is used as a generic synonym for rational, logical, practical, fair, realistic, and sensible. On this understanding, the ICRP recommended that some exposure situations may be excluded from radiological protection control legislation, usually on the basis that they cannot be controlled by reasonable means, i.e. they are uncontrollable or unamenable to be controlled with regulatory instruments. Similarly, some controllable exposure situations may be exempted from some or all radiological protection regulatory control requirements because such controls may be reasonably regarded as unwarranted.

4.2. Guidance on regulatory scope

A few months after ICRP Publication 103 was published, in September 2007, the ICRP issued recommendations on the elusive issue of regulatory scope. In ICRP Publication 104 [4], the Commission recommends approaches to national authorities for the definition of the scope of radiological protection control measures through regulations, by using its principles of justification and optimization. The report provides advice for deciding the radiation exposure situations that should be covered by the relevant regulations because their regulatory control can be justified, and, conversely, those that may be considered for exclusion from the regulations because their regulatory control is deemed to be unamenable and unjustified. It also provides advice on the situations resulting from regulated circumstances which may be considered by regulators for exemption from complying with specific requirements because the application of these requirements is unwarranted and exemption is the optimum option. Thus, the report describes exclusion criteria for defining the scope of radiological protection regulations, exemption criteria for planned exposure situations, and the application of these concepts in emergency exposure situations and in existing exposure situations. The report also addresses specific exposure situations such as exposure to low energy or low intensity adventitious radiation, cosmic radiation, naturally occurring radioactive materials, radon, commodities, and low level radioactive waste. The quantitative criteria in the report are intended only as generic suggestions to regulators for defining the regulatory scope, on the understanding that the definitive boundaries for establishing the situations that can be or need to be regulated will depend on national approaches.

5. PRESENT INTERNATIONAL CONSENSUSES

In summary, there is an international consensus on the paradigm for the scope of radiological regulatory control, which can be briefly described as follows: (a) exposure situations that are deemed to be uncontrollable or unamenable to control shall be excluded from radiation protection legislation; (b) exposure situations that are covered by the legislation but for which control is unwarranted under some circumstances shall be exempted from regulatory requirements by the regulators (when control becomes unwarranted *a posteriori*, the situation is said to be cleared of regulatory control). Thus, the scope of radiation protection regulations for exposure situations can be summarized as follows:

(i) Until now the important consensus on exclusion has not materialized in specific legislation. Most legal systems however, in practice, exclude obviously uncontrollable situations such as exposure to homeostatically controlled ^{40}K in the body and cosmic rays at ground level. Less clear is the legislative consideration concerning natural radioactive materials having unmodified activity concentrations.

(ii) Radiation sources whose activity, at any one time, does not exceed the values specified in the BSS [1] (Schedule I, Table I-1), or radioactive materials whose activity concentration in amounts of 1 ton or less does not exceed the values specified in the BSS [1] (Schedule I, Table I-1), can be exempted from the regulatory requirements of notification, authorization and licensing. The activities range from 10^3 Bq to 10^{12} Bq and the activities concentrations range from 1 to 10^6 Bq/g

(iii) Regulated inedible radioactive materials whose activity concentration, irrespective of the amount, does not exceed the values specified in the guidance on 'Application of the Concepts of Exclusion, Exemption and

Clearance' [47, 48] can be removed from regulatory control. The activity concentrations range from 0.01 Bq/g for ^{129}I up to 10 000 Bq/g for ^{103m}Rh and ^{254}Fm. However, natural radionuclides in the primordial natural decay chains in secular equilibrium may not be regulated at activities concentrations below 1 Bq/g (that is, the primordial decay chains headed by ^{238}U, ^{235}U or ^{232}Th, with the value given to be applied to the parent of the decay chain) — namely two orders of magnitude higher than the lower value for the artificial radionuclide ^{129}I. For the pervasive ^{40}K the value is still higher: 10 Bq/g. It is to be noted that the primordial chains contain many alpha-emitting radionuclides with high radiotoxicity (elevated levels of dose per unit intake). The activity or the activity concentration of radioactive materials being transported, irrespective of the amount, should not exceed the values specified in the Transport Regulations [49]. The activities for exempt consignments range from 10^3 Bq to 10^{10} Bq and the activities concentrations for exempt material range from 10^{-1} Bq/g to 10^6 Bq/g.

(iv) Foodstuff whose activity concentration does not exceed the values established in the Codex Alimentarius [68] can be traded as human and animal food.

(v) Water whose activity concentration does not exceed the levels established in the WHO's Guidelines for Drinking-water Quality [69] can be used as drinking water.

6. CRITICAL ANALYSIS

Analyzing the current situation it is to be noted that:

(i) The several orders of magnitude span of the range of activities and activities concentrations at which control can be relinquished and the exoticism of some of the radionuclides included is clear evidence that still there is a long way to go until a practical global agreement can be reached on what merits control and what does not.

(ii) The activity concentrations at which clearance of inedible commodities can be permitted, for radionuclides that are usually present as inadvertent radioactive material in scrap metal, are in a close range: for ^{60}Co and ^{137}Cs the level is 0.1 Bq/g; for ^{190}Ir it is 1 Bq/g.

(iii) However, the clearance values for the common radionuclides ^{60}Co and ^{137}Cs are one order of magnitude lower than the clearance values for the radionuclides of the natural primordial chains despite the fact that the radiotoxicity of the latter may be higher. One approach to quantify radiotoxicity approximately is via the committed effective dose per unit intake (which is usually expressed in Sv Bq^{-1}). The (adult) values for ^{60}Co range from 9.6×10^{-9} to 3.4×10^{-9}. For ^{137}Cs, they range from 4.8×10^{-9} to 1.3×10^{-8}. For the head of the primordial chains they range: for ^{232}Th, from 2.0×10^{-4} to 9.2×10^{-8}; for ^{238}U from 4.9×10^{-7} to 4.4×10^{-8}, and for ^{235}U from 1.8×10^{-6} to 8.3×10^{-9}. It is obvious that it is difficult to defend the rationality of the clearance levels for ^{60}Co and ^{137}Cs in relation to those for the primordial chains.

(iv) Surprisingly, some of the Codex Alimentarius levels that permit clearance of edible commodities are higher than those that permit clearance of inedible materials; for instance, for ^{137}Cs and ^{60}Co the Codex level for foodstuffs is 1Bq/g, or one order of magnitude higher than the level for inedible commodities. In practice, this means that if metals contaminated with ^{137}Cs and ^{60}Co were edible they would be authorized to be eaten (on radiation protection grounds) but not to be used as an inedible commodity; — for instance as rebar or cast iron furniture. How is such measurement possible? The reason is illogical but simple: as radiation protection specialists have focused attention on dose rather than activity, the exposure to the activity concentration in the product has to be modelled to assess dose and it is easier to model exposure to edible than to inedible commodities. Human ingestion and dosimetry models are straightforward, while models for estimating the hypothetical doses that human can incur from contaminated metal products depend on the imagination of the modeller!

7. OUTLOOK: THE WAY FORWARD

The intergovernmental agreements already reached for clearing commodities from radiation protection control are an important advance in the right direction. However, it is obvious from the analysis above that there are still incoherencies and inconsistencies and the system may not be ideal for solving current problems.

It is submitted that the following issues need to be tackled to solve the current conundrum, namely:

— The semantics for addressing the issue of radioactive substances present in commodities, particularly the presence of inadvertent radioactive traces in metal products, should be improved;

— The focus in deregulation should move from dose to activity concentration and the values should be simply expressed. Ideally the criteria should be radionuclide independent even if this means that they are more restrictive for some radionuclides than others.

7.1. Improving semantics

The term radioactive **'contamination'** may be responsible for many artificial radiation protection conflicts [58]. A mistaken connotation is given to the concept of 'contamination' of commodities in general and of metals in particular. The term is widely misunderstood and its misinterpretation has had enormous effects in strategies for the radiological control of commodities. Surprisingly, the term derives from an historical religious background for describing impurity[1]. The obvious implication of this is that something that is 'contaminated' is automatically unacceptable regardless of the quantification of such 'contamination'. A typical example of this use is the religious understanding of 'contaminated' (e.g. no-kosher) food, namely food not satisfying the requirements of religious law with regard to its origin and preparation. Thus, a 'contaminated' commodity, whatever the level of its contamination, is (at least grammatically) religiously impure. The experts' intention is to describe an amount of a radionuclide, in a given energy state at a given time, in a given amount of material, rather than to suggest impurity or dirtiness. However, in the public mind, radioactive 'contamination' of a product is a quasi-synonym of radiation-related dangerousness.

It is worthwhile to note the evolution of the concept in the Codex Alimentarius. The Codex defines a contaminant as 'any substance not intentionally added to food, which is present in such food as a result of the production, manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination'. (Surprisingly, the Codex notes that the term does not include 'insect fragments, rodent hairs and other 'extraneous matter') However, there is no food producer advertising its products with a label of the type: "please note that this food contains contaminants below the Codex Alimentarius levels except for insect fragments, rodent hairs and other 'extraneous matter'". No food producer would do that. But this is what radiation protection regulators implicitly force producers of inedible commodities to do. In summary, it is submitted that the semantics for conveying the real meaning of 'contamination' in commodities in general, and metals in particular, should be improved by the radiation protection community. If this is not achieved continuing problems over public acceptance may be expected.

[1] Contamination originates from the Latin *contaminat-*, *contaminare*, or 'make impure', from *contamen* 'contact, pollution', from *con-* 'together with' plus the base of *tangere* 'to touch'.

7.2. Regulating traces of radioactive substances in metals

The regulators of radioactive substances in metals should learn from the long experience of regulating contaminants in foodstuffs. The food industry and the consuming public have accepted that totally pure food is unattainable and that the presence of contaminant traces in foodstuffs does not seem to be a public issue. There is an international benchmark for determining whether traces are a public health issue, namely the Codex Alimentarius. The Codex, in addition, establishes actions for preventing or reducing contamination of foods and feeds, for instance: preventing food contamination at the source, e.g. by reducing environmental pollution; applying appropriate technology in food production, handling, storage, processing and packaging; applying measures aimed at decontamination of contaminated food or feed; and, applying measures to prevent contaminated food or feed being marketed for consumption.

These actions could be transferred to the metal market as follows: preventing metal contamination at the source, e.g. by an international convention that prevent controls of radioactive sources being relinquished; applying appropriate technology in metal production, e.g. allowing early detection of contaminated scrap; applying measures aimed at decontamination of contaminated metals, e.g. by diluting the contamination; and, applying measures to prevent contaminated metals being marketed for consumption, e.g. by monitoring outputs.

In summary, for regulating traces of radioactive substances in metals the following approaches are suggested

A clear triggering criterion of ‘radiological normalness’ is needed for metals. It should establish a clear divide between radioactivity levels that are considered to be a public health issue, and therefore need regulation, and those levels that are considered not to be a public health issue, below which any product should be free from radiological regulation. The straightforwardness and authoritativeness of the criterion will more important than the numbers it contains and its values should be simpler than the current clearance levels. Moreover, they should be authoritative *de-minimis-non-curat-lex* levels, namely ‘exclusion’ levels to be established by legislative instruments rather than *de-minimis-non-curat-prœtor* levels, namely ‘exemptions/clearances’ that are decided by regulators.

- The ultimate solution would be to agree on a kind of ‘Codex Metallarius’, similar as an undertaking to the Codex Alimentarius.
- The practical exclusion levels established in the first international radiation protection standards, namely 74 Bq/g (370 Bq/g for natural radionuclides) [41], were never blamed for generating a public health problem. It seems therefore that a Codex Metallarius establishing a generic exclusion level of

the order of tens of Bq/g would provide adequate protection for people and, in addition, effectively solve all major current problems. Using reasonable modelling assumptions it is hard to believe that individual doses from inedible commodities at these levels of activity concentration for any radionuclide could exceed some μSv per annum, namely a minute fraction of natural background doses and usually lower that the natural variation of these doses.

— However, so much anxiety has been created by this problem, and it has been ignored by public authorities for so long, that it would be extremely difficult to obtain public acceptance for values higher than the current clearance levels, namely around 0.1 Bq/g. The fact that they are derived from extremely conservative modelling would probably be irrelevant for a suspicious public.

— Perhaps the ultimate compromise could be a generic, simple, radionuclide independent exclusion level of 1Bq/g. After all, this would be an easily communicable round number that could obtain general acceptance and still solve many of the current problems.

— A Codex Metallarius containing reasonable exclusion levels adopted as an intergovernmental legally binding undertaking would be a very desirable international solution. Similar to the legally binding undertaking that is still required for preventing the loss of control of significant radiation sources!

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ACTIVITIES AND ISSUES IN MONITORING SCRAP METAL AGAINST RADIOACTIVE SOURCES

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Abstract

Over the past few decades, the global scrap metal industry has grown increasingly vigilant regarding radioactive contamination. Accidental melts of radioactive sources in some smelting facilities, in particular, have caused considerable damage and required recovery efforts costing tens of millions of dollars. In response, the industry has developed and deployed countermeasures. Increasingly expensive and sophisticated radiation monitoring devices have been implemented at key scrap entry points — ports and scrapyards. Recognition of the importance of such endeavors has led to a series of activities aimed at establishing organized and coordinated efforts among the interested parties. Recent concerns over the potential use of radioactive sources for radiological devices in terrorist acts have substantially heightened the need for national and international authorities to further control, intercept, and secure the sources that have escaped the regulatory domain. Enhanced collaboration by the government and industry could substantially improve the effectiveness of efforts at control; the 'Spanish Protocol' as developed by the Spanish metal industry and government regulators is a good example of such collaboration.

1. INTRODUCTION

Radioactive material has long been considered a highly undesirable contaminant by the metal manufacturing industry. In addition to the generally negative public perception of radioactivity in metal products, the industry's major concern is the potential for contamination of its mills by radioactive material originating from radioactive sources in scrap metal. Such incidents have been reported throughout the world; in severe cases, the costs to the metal recycling facilities have ranged in the order of \$8 million to \$10 million (US dollars); this is in addition to the excess radiation exposures to workers as well as to the general public [1–3]. The metal recycling industry, for example, has employed radiation detection systems to intercept radioactive contamination, thus adding tens of thousands of US dollars to its operational costs, which usually exceed \$100 000 (U.S. dollars) per site [3, 4]. Since the beginning of reporting in the United States in 1983, more than 500 incidents have been recorded; the number peaked in 1995

[5]. The occurrence of incidents persists worldwide [6], which suggests a need for continued control over radioactive sources.

In the United States of America (USA), some government agencies — Environmental Protection Agency (EPA), Department of Energy (DOE), and the Nuclear Regulatory Commission (NRC) — have increased efforts to address the monitoring and control of orphan sources. The Department of Homeland Security (DHS) has also given increased attention by patrolling and monitoring the nation's borders for illicit trafficking of nuclear materials and radioactive sources. These activities have been closely coordinated with international agencies, including the United Nations Economic Commission for Europe (UNECE), the European Union (EU), and the International Atomic Energy Agency (IAEA).

2. MONITORING AND INDUSTRY ISSUES

2.1. Monitoring approaches

Monitoring and surveillance of US domestic scrap metal usually occurs at three locations: (1) generator sites, (2) scrapyards and mills, and (3) in plants [3]. The generator sites of interest are usually the demolition sites of former nuclear facilities where abundant scrap metal can be recovered for recycling. Handheld survey meters are often used to check and 'clear' the metals of potential contamination [7]. Today, it is standard practice for scrapyards and steel mills to install large volume plastic scintillation detectors as portal monitors for surveying the incoming scrap. In addition to detecting gamma rays, such monitors can detect neutrons, and sometimes the bremsstrahlung rays produced by energetic beta radiations from sources such as ^{90}Sr [3]. In-plant monitoring includes three modalities: (1) monitoring the charge bucket during loading, (2) mounting a detector on the crane during scrap loading, and (3) installing a detector system on conveyors for sorting the scrap [3]. The combination of these monitoring methods usually provides a reasonably effective means of detecting radioactive sources.

2.2. Industry issues

Notwithstanding the increased sophistication in monitoring the incoming scrap, issues remain. The inability of the monitors to distinguish human-made radioactive sources from those of NORM (naturally occurring radioactive material) or TENORM (technologically enhanced naturally occurring radioactive material) have caused frequent false alarms. Such incidents decrease the effectiveness and reliability of the system. Further, there is always a need to improve the sensitivity of the instrument for detecting potential sources hidden within the scrap piles.

In addition to coping with the potential contamination in metal products, the industry has been compelled to deal with an array of institutional issues with which it is not familiar. First, radioactive sources are generally controlled materials owned by licensees of regulators such as the NRC. Finding such sources usually indicates inadvertent or illicit transfer or disposition of the radioactive sources, which the industry in general is not amenable to managing. Yet little or no mechanism exists for recourse once the source is found, resulting in a potential penalty to the metal industry. Second, financial protection against large scale radioactive contamination is not easy to find; for example, insurance coverage for such incidents is either cost-prohibitive or simply unavailable [3]. Thus some degree of government assistance would be required.

3. MONITORING AND CONTROL OF RADIOACTIVE SOURCES

In the past decade, a number of initiatives in the USA have sought to improve the monitoring and control of radioactive sources. Some international activities, organized by the UNECE, EU, and IAEA, have also helped provide global coordination and assistance in that regard. The level of urgency of such activities has been heightened since the 9/11 terrorist attack. Control over radioactive orphan sources needs to be exerted in order to prevent their use as radiological dispersal devices (RDDs) in an act of terrorism. Highlighted below are some major programmes initiated both in the United States and also internationally.

3.1. US efforts

In 2001, the EPA, at the request of the US Customs Service, initiated a pilot study to investigate the feasibility of safeguarding imported scrap metal against the illicit or inadvertent inclusion of radioactive contamination. A pilot test was first conducted at New Orleans, Louisiana, followed by Charleston, South Carolina, with a grapple-mounted radiation detector system and remote monitoring. The pilot test monitored more than 2.3 million gross tons of scrap metal off-loaded at the two ports. The project demonstrated the feasibility of such a system, and the necessary protocols were developed [8].

The Off-Site Source Recovery Project (OSRP) was established by DOE in the late 1990s to meet a Congressional mandate for recovering a backlog of unwanted or orphan sealed sources across the USA. In 2003, the project was undertaken by DOE's National Nuclear Security Administration (NNSA) as part of its Global Threat Reduction Initiative. The OSRP project covers an array of sources, including actinides and beta- and gamma-emitting sources. The source management approaches include recycling, storage, and disposal. The OSRP is currently managed at DOE's Los Alamos National Laboratory. Since 1999, more than 19 000 sources from over 700 sites have been recovered from industry, academia, healthcare facilities, and government agencies.

In an effort to strengthen its regulatory measures for controlling radioactive sources, the NRC has expanded its collaborative effort with the IAEA, other domestic agencies, and Agreement States to help secure nuclear materials and radioactive sources. In 2006, the NRC issued a final rule incorporating the National Source Tracking System (NSTS) into its regulation oversight. The NSTS created a web based national registry for Category 1 and 2 sources for the first time.

Since its inception in 2002, DHS has initiated, and through collaborations with various agencies, programmes aimed at protecting U.S. borders against the illicit trafficking of nuclear materials or radioactive sources. In 2006, DHS joined forces with DOE in launching the Secure Freight Initiative, intended to enhance the federal government's ability to scan containers for nuclear and radioactive materials overseas and to better assess the risk of inbound containers. This initiative was built upon DOE's NNSA Megaports Initiative, which deployed radiation detection equipment at some foreign ports, and DHS's own Container Security Initiative to monitor high-risk containers at foreign seaports.

3.2. International efforts

At the international level, one major document, Code of Conduct on the Safety of Radioactive Sources [9], provides a framework for ensuring the radiation safety and security of radioactive sources. A document on the control of radioactive sources was published earlier by the EU [10].

In 2001, the UNECE, EU, and IAEA prepared a report [11] that makes recommendations for addressing radioactive contamination issues in the metal recycling stream. The UNECE subsequently organized a series of meetings of an international Group of Experts and issued its findings and recommendations [12, 13]. The latter document [13] offers recommendations on the development of a voluntary international 'Protocol' that represents good practice as well as building on national and international experiences in monitoring scrap metal. It encourages cooperation, coordination, and harmonization of approaches among nations to further promote international trade.

4. IMPROVEMENT THROUGH COLLBORATIVE EFFORTS

Orphan sources have been widely recognized as a hazard by society in general. To the metal industry, it is of utmost importance to screen scrap metal for contamination to protect the trade. The priority of nuclear regulators is to ensure that the licensed radioactive sources are used as intended, thus safeguarding against illicit transfer or loss of the sources is critical. Major efforts have also been undertaken by homeland security sectors in terms of intelligence collection and analysis; tracking, collection, and disposition of sources; development and deployment of monitoring technology; and development of necessary procedures and protocols for detection, training, and reporting. A meaningful collaborative effort among all interested parties would (a) address mutual benefits, (b) share information and technology, and (c) harmonize individual efforts.

4.1. Spanish protocol

In Spain, early recognition of the need for government-industry collaboration led to the development of the Spanish Protocol (Protocol for Collaboration on the Radiation Monitoring of Metal Materials) [14]. The Spanish Protocol has been recognized as a new mechanism to facilitate the creation of a favorable environment to address the metal industry's concerns in monitoring scrap metal [3, 14]. The Protocol sets up a legal framework under which the subscribing companies can obtain government assistance through expert advice and training and related assistance in the monitoring of radioactive materials in scrap metal. In the event of an accidental melt, the relevant government agencies would manage the radioactive materials. In return, the subscribing companies would adhere to the government-sanctioned standards, detection systems, and monitoring protocols for scrap metal. The Protocol provides a viable mechanism for appropriately engaging the regulatory sector and the metal industry — an industry not amenable to radioactive material regulations.

4.2. Further collaborative efforts

The positive aspects of the Spanish Protocol suggest that additional benefits could be realized by further advancing the collaborative effort among all interested parties. For example, the extensive radiation detection technology developed under national security initiatives would offer the metal industry advanced devices that can readily help identify radionuclide species. Conversely, timely incident reporting from the mills could also serve as valuable intelligence information that could strengthen homeland security efforts. Further sharing of information (e.g. creating a consistent international protocol, developing a web based information system, and conducting training [13]) among domestic and international agencies could promote a cohesive approach and operation aimed at stopping the loss of radioactive sources from control.

It should be emphasized that such collaboration may also lead to the industry's (and also the public's) acceptance of the clearance concept [15]; that is, the release of materials (including metals) containing residual radioactivity would be allowed from regulated facilities. While the clearance approach and standards have been well established by the IAEA [16], strong opposition in the USA continues to stall the regulatory development effort [17]. An improved working environment through a constructive, collaborative effort might lead to a better reception by the industry of the released metals from the nuclear facilities.

5. DISCUSSION AND CONCLUSIONS

Scrap metal monitoring for radioactive sources has long been an issue for the scrap metal industry and accidental melts of radioactive sources continue to be reported worldwide. The industry has attempted to address the relevant issues in order to safeguard its trade against contamination. Nonetheless, the relevant issues are far-reaching and the industry cannot confront them alone, primarily because it has little or no control over the transfer and disposition of orphan sources. Collaborative efforts aimed at promoting a coordinated and consistent approach to prevent incidents and to alleviate potential impacts have been initiated both domestically and internationally. Further initiatives are needed to engage all sectors (i.e. scrap metal industry, regulators, and agencies in homeland security). While each sector has different objectives, they could all benefit substantially from closer collaboration.

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SLOVENIAN SYSTEM FOR PROTECTING AGAINST RADIOACTIVE MATERIAL IN SCRAP METAL SHIPMENTS

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Abstract

The Slovenian experience shows that the majority of detected orphan sources are associated with imports of scrap metal to Slovenia and transits of that material through Slovenia. Such orphan sources originate from past industrial activities and weak regulatory control in the countries of origin. In order to minimise the number of sources outside regulatory control several regulatory and law enforcement measures have been implemented. To prevent illicit trafficking across the border the 'First line of defence' — customs and police — are equipped with radiation detection devices. Since 2002, the Slovenian Nuclear Safety Administration (SNSA) has provided a 24-hour on-duty officer, who gives advice in case of the discovery of an orphan source. The majority of scrap metal collectors and re-cyclers are equipped with portal monitors and/or hand-held radiation detection equipment. Generally, good cooperation has been established between different organizations within Slovenia, with neighbouring countries and with some international organizations. To regulate the scrap metal activities, a new Decree on checking the radioactivity of shipments of metal scrap has been in force since 1 January 2008. This decree requires that every importer has to present a certificate of radiation measurement before any shipment of scrap metal is brought into Slovenia. Such measurements can be performed only by certified organizations. These organizations can obtain certification from the SNSA providing that they have the prescribed measuring devices, adequate training and procedures, and that their capabilities have been checked by a technical support organization. The experience after one year of application of the decree is positive. Awareness, including the adequacy of response, has increased. The paper discusses the general scheme for protection against illicit radioactive material in scrap metal shipments and the Slovenian experience in the last decade.

1. INTRODUCTION

The presence of radioactive materials in recycled scrap metals may have serious consequences for the economy of companies, the safety of the environment and, in certain cases, the health of workers and members of the public.

At the beginning of this decade, various international organizations (e.g. IAEA, INTERPOL, WHO, etc.) introduced initiatives and made recommendations, addressing prevention, detection, and response for such incidents [1–8]. Additionally, some countries made their own domestic arrangements, based on the experience of past incidents [9]. In combating illicit trafficking of nuclear material, certain developed countries donated detection equipment and/or provided training. Deliberate and inadvertent illicit trafficking of smaller amounts of nuclear and radioactive material in the first half of the 1990s in Eastern Europe and the Caucasus region has prompted several coordinated preventative actions.

In Slovenia, no serious events of this type have occurred so far. In the last two decades, a few radioactive sources were melted causing only limited economic impact. In addition, there were notable refusals of scrap metal shipments by Italian border authorities. The shipments originated either from Slovenia or from neighbouring countries (from former Yugoslav Republics in particular). The major Slovenian metal scrap recycling companies detected and isolated orphan sources using their own radiation detection systems.

These events caused growing concern about possible incidents and the possibility of illegal transfer of radioactive waste into Slovenia. In order to prevent such events, the Slovenian authorities implemented several regulatory and law enforcement measures.

2. PAST AND CURRENT SLOVENIAN EXPERIENCE REGARDING ORPHAN SOURCES IN SCRAP METAL

The Slovenian experience shows that, in most cases, the orphan sources were associated with the import of scrap metal into Slovenia and the transit of such material through Slovenia [10, 11]. These orphan sources usually originate from past industrial and military activities in countries with weaker regulatory control systems. However, there have been noticeable improvements in the region in recent times.

The Italian border controls have discovered elevated radiation in scrap metal shipments on several occasions and denied their entry into Italy. The sources found in these shipments were isolated and transferred to the central low and intermediate level radioactive waste storage facility at Brinje (CSRAO). The sources found contained europium-152/154, caesium-137, thorium-232 and radium-226.

In 2004, a metal piece contaminated with naturally occurring radioactive material (NORM) was found in an ironworks and a cobalt-60 source without shielding was found in another ironworks. Both items were transferred to CSRAO.

There have also been cases of denied transit shipments, e.g. a Yugoslav shipment was turned back at the Slovenian border. Slovenia has also denied several shipments coming from Croatia at the Gruškovje and Zavrč border crossings. Cobalt-60 and europium-152/154 were identified in most cases when sources were found.

In 2001, a cobalt-60 source (80 MBq) was unknowingly melted and the Slovenian Nuclear Safety Administration (SNSA), for the first time, notified the IAEA Illicit Trafficking Database. Fortunately there were no significant releases into the environment after the sources were melted. Due to the behaviour of cobalt-60 on being melted, only the metal products were contaminated.

Prior to 2003, all known cases were investigated by the Health Inspectorate of Slovenia (HIRS) and corrective measures were implemented. In one case (caesium-137, 2003), an investigation took place which included cooperation with Croatia, Germany and INTERPOL.

Most of the shipments are returned to the consignors, mainly in former Yugoslav republics. Italy has maintained a strict control on the Italian-Slovenian border even after the extension of the EU extension. Italian private companies (e.g. Multiproject, s.r.l.) perform measurements on all shipments of scrap metal and have the power and mandate to deny their entry. In cases of significant increases in radiation levels, the source is isolated and stored safely in Italy. The number of denials has dropped significantly in the last couple of years.

If the orphan sources found in a denied shipment of scrap metal are of Slovenian origin, they are stored at CSRAO. This is also the procedure when scrap metal shipments are imported into Slovenia and later exported (shipped out) and denied entry into a neighbouring country. It is quite difficult to return a radioactive source to the country of origin if a Slovenian company imports the shipment and the ownership becomes theirs. Slovenia does not wish to be ‘a disposal site’ for orphan sources from abroad. The problem is not crucial but has to be addressed. In the case of shipments in transit which are denied entry but returned to the country of origin, practically no costs are imposed on Slovenia. Transits to Italy outnumber those to Austria and Germany.

Scrap containing radium-226, including NORM, amounts to nearly 80% of all cases. These cases are followed by those involving orphan sources, previously used in industry (12%), lightning conductors (usually with europium-152/154) (below 10%) and other items (e.g. thorium-bearing alloys) (less than 5%). These ratios are similar to those presented by other EU countries

FIG. 1 shows one of the recently discovered sources containing radium-226 (contact dose rate about 2 mSv/h) which was detected in summer 2008 at one of the largest scrap metal yards in Ljubljana.

FIG. 1. Radium-226 — orphan source.

3. COOPERATION BETWEEN CUSTOMS, POLICE, SNSA AND OTHERS

The first coordinated activity of Slovenian governmental bodies started at the beginning of the 1990s when the US Export Control Office was established in Ljubljana for the region. The USA donated to the Slovenian authorities various types of instruments to be used in the prevention of inadvertent movement and illicit trafficking of nuclear material and radioactive sources. Over 100 radiation detection devices have been deployed since 2002. SNSA, together with the Customs, Ministry of the Interior and HIRS organised a seminar in June 2002 for the 'front-line officers'. The customs and police officers also received training on procedures for internal use, as well as harmonized inter-agency procedures which have been recently revised together with the reporting forms. They become involved when elevated radiation levels are detected and verified. It could also start on the basis of intelligence information gathered from various sources. In case of suspicion of any unauthorized movement or malicious activities with radioactive sources, the regulatory agencies will take appropriate measures (tighter border and traffic control etc).

Since 2002 the SNSA has provided a 24-hour on-duty officer who provides advice in the event of discovery of an orphan source or in the event of detection of elevated radiation levels. This support is available to other governmental bodies as well as to private organizations (i.e. scrap metal collectors and recyclers, Slovenian railways). Statistics on the received calls are shown in Table 1 below.

The larger scrap metal collectors and metal recyclers are fairly well equipped with radiation monitoring equipment. This started in the second half of

TABLE 1. PURPOSE AND NUMBER OF CALLS TO THE ON-DUTY OFFICER AT THE SNSA SINCE 2002

Year	Cause				Total
	Radioactive source or elevated radiation	NORM	Medical Patients	Other	
2002 (since 12 June)	0	1	2	3	6
2003	2	3	4	1	10
2004	2	2	2	0	6
2005	5	5	0	1	11
2006	3	2	1	3	9
2007	2	7	1	2	12
2008	1	1	1	1	4
2009 (end of January)	0	1	0	0	1
					59

the 1990s after several meltings of radioactive sources occurred. In particular, some high quality ironworks and (mainly) aluminium foundries, because of their concern over potential consequences and possible economic impacts, installed several portal monitors and also acquired hand-held devices. Some of the other scrap collectors are equipped with hand-held devices (survey meters) and there are a limited number of portal devices. Small collectors and foundries are rarely equipped with monitoring devices but the risk is also less. A greater awareness of the risk posed by orphan sources is also achieved through occasional workshops for customs, police, scrap metal collectors and metal recyclers and others.

SNSA has cooperated with the Criminal Police (i.e. Ministry of the Interior) since 2003 in assessing the number and location of high-activity sources (or in IAEA terminology: ‘dangerous sources’). There are less than 20 companies and organizations in Slovenia possessing such sources. The police have visited them occasionally and (where necessary) proposed some corrective measures and other inputs.

SNSA intensified its inspection control with the aim of decreasing the number of radioactive sources outside regulatory control or those in situations where regulatory control is weak (i.e. vulnerable sources). For example, in 2004, an industrial gauge with a caesium-137 source was found by an SNSA inspection at the premises of a former bankrupted company and was subsequently safely dismantled and transferred to CSRAO. SNSA inspection discovered at a faculty of the University of Ljubljana a caesium-137 source that had been inadequately stored at a place to which there was easy access. SNSA inspection has also resulted in the discovery of several low activity radioactive sources and nuclear substances at different institutes, faculties and companies. In the near future, a special challenge will be to inspect a number of sources used by different services within the Ministry of Defence.

There have been several campaigns aimed at decreasing the number of disused/spent sources at various premises, e.g. cobalt-60, radium-226, thorium and uranium containing materials, depleted uranium, smoke detectors with mainly americium-241 sources, calibration sources deploying strontium-90, lightning conductors — usually with europium-152/154 sources. The SNSA issues ‘Radiation News’ (Sevalne novice) on a quarterly basis, intended for radiation practitioners and others, with the aim at sharing information on legislation requirements, lessons learnt, etc. Extensive information can also be found at the SNSA web site (www.ursjv.gov.si).

4. DECREE ON THE CONTROL OF RADIOACTIVE CONTAMINATION IN SHIPMENTS OF SCRAP METAL

After several months of preparation and consultations with the industry, the Decree on checking shipments of metal scrap for radioactivity was prepared by the SNSA in 2006 and entered into force on 1 January 2008. The basic idea of the decree is that every shipment of scrap metal with its final destination in Slovenia must be subjected to measurement of radiation and this has to be assured by the consignee. The report of the measurements made has to be presented to the consignee and to the customs in case of import. The import can be approved only if the results of measurements are satisfactory. The measurements can be performed only by those organizations which are authorized by the SNSA; the organizations must fulfil a set of prescribed qualitative and quantitative criteria (detection devices, training for personnel, reporting forms and procedures (measuring protocol), a positive opinion from a technical support organization, i.e. certified expert). The organization which performs the measurements of radioactivity can be the consignee.

In case of elevated radiation at more than 50% above natural background, but lower than 50 times the natural background, the import of the shipment is rejected and the SNSA has to be informed. The shipment has to be returned to the country of origin. In such a case the authorities of that country are informed.

Radiation safety measures are stricter if the maximum dose rate exceeds 50 times natural background. In such a case, the consignee of the shipment has to implement all measures prescribed by inspectors and to provide for adequate

FIG. 2. Fixed systems for detection of elevated radiation/orphan sources.

management of the found source, including its disposal as radioactive waste. For that purpose the Agency for Radioactive Waste Management is usually involved and such sources are sent to the central low and intermediate level radioactive waste storage facility at Brinje (CSRAO).

If radioactive sources are found and their discoverer as well as their owner is a Slovenian company, all costs of recovery, transport, handling and storing in CSRAO are born by this company ('polluter-pays' principle) which may, based mainly on the contract's conditions, require necessary reimbursement from the consignor, if known. Thus, no additional costs are imposed on the national budget.

The decree also covers internal control of radioactivity in scrap metal, in particular at those facilities where recycling occurs (e.g. melting). Figure 2 shows a pair of portal monitors, located in Ljubljana at the premises of a company dealing with collection and recycling of different scrap.

After one year of the application of the Decree, 20 organizations had been authorized to monitor scrap metal shipments. They are located throughout Slovenia and nearly half of them are foundries. Their authorisation is valid only for two years but can be extended. There are some newer/emerging companies with portable detectors and/or fixed detection systems as well as those companies which acquired equipment in the 1990s. The organizations, performing measurements of radioactivity have to report annually to the SNSA.

4.1. Summary of annual reports for 2008

In summary, 17 organizations (out of 18) had provided their annual reports by the end of February 2008. The organizations concerned are ironworks, foundries, producers of aluminium, scrap recyclers and dealers and forwarding agents. Partial data analysis shows that iron and steel scrap is the main type of scrap being monitored (nearly 90% of total). The remaining scrap is either aluminium, copper, zinc and their alloys, mixed scrap or some other metal.

Altogether, elevated radiation levels were observed on eight shipments. Seven were measured by Slovene experts and the remaining one by the Austrian experts. A short overview of these cases is listed — based on their potential risk:

- A Slovene scrap recycler detected elevated radiation and identified radium-226. Subsequently, a metal piece with a contact dose rate of 2.9 mSv/h (A ≤ 200 MBq) was isolated and safely stored in CSRAO.
- A Slovene scrap recycler did not detect any elevation of radiation at the exit of his facility but the shipment triggered an alarm in Austria. Subsequently, an ionising smoke detector was found, containing radium-226, with a contact dose rate of 0.1 mSv/h. It was sent for storage at Seibersdorf, Austria.
- A shipment, originated from Croatia, triggered an alarm due to iodine-131. The maximum dose rate was less than 0.02 mSv/h. The contaminated containers (made of lead) were temporarily stored in Slovenia (at the consignee's premises) until their unconditional release.
- Three cases were reported by a Slovene recycler who detected elevated radiation levels due to NORM. Dose rates were up to 10 times above natural background.
- A shipment of electronic (waste) equipment (glass) triggered alarm due to a slightly elevated radiation dose rate. It was found to be due to NORM and the radionuclides radium-226, potassium-40 and thorium-232.

4.2. General conclusions after one year

- The larger scrap metal dealers bought the necessary equipment, trained their staff and received authorization for monitoring scrap metal shipments;
- There were no significant complaints because of the additional work and costs entailed;
- The number of denied shipments of scrap metal on the Italian-Slovenian border dropped sharply starting at the beginning of 2007;
- The number of calls to the 24-hour on-duty officer (SNSA) dropped by 60% in the year 2008;
- Small and medium sized foundries have not yet applied for authorizations for the monitoring of scrap metal shipments (but the risk of orphan sources is smaller);

— The customs and some representatives from industry have preliminarily proposed that the Decree should be amended and the list of metal scrap types (waste) revised;
— The Decree itself imposes no additional costs to the State's budget;
— It seems that an effective and inexpensive solution has been found.

5. INADVERTENT MOVEMENT AND DELIBERATE ILLICIT TRAFFICKING

Slovenia has reported to the IAEA ITDB five times so far. All cases were assessed as ‘inadvertent movement’. There is no evidence of deliberate illicit trafficking across Slovenian borders or territory.

In recent years, and particularly after 11 September 2001, there are additional concerns worldwide about the possible consequences of nuclear smuggling and the use of radiological dispersal devices (RDD). Security issue is becoming more and more important and IAEA and others have been preparing guidelines and recommendations in this regard. The International Convention for the Suppression of Acts of Nuclear Terrorism of 2005 is an important step toward global awareness and the coordination of efforts. Nuclear security at major public events, threat assessment and deployment of detection devices are routine activities (e.g. during the 2004 Olympics in Athens and the Pan-American Games in Brazil in 2007). The USA coordinates, inter-regionally, a number of different projects. In this context, Slovenian governmental bodies have received various instruments, software and training. Some adjacent topics have also been addressed (dual-use items, chemical-biological weapons/precursors etc.). In 2005, an agreement was signed between the Ministry of Finance and the US Department of Energy, on Cooperation to combat illicit trafficking of nuclear and radioactive materials. Based on this agreement, inter alia, fixed portal monitors were installed at Koper and Obrežje (road border crossing). Both pedestrian and vehicles' lines are monitored.

The main aim of the USA, in this context, is to detect nuclear smuggling (fissile material) as well as dangerous radioactive sources, suitable for assembling a RDD. However, the monitoring equipment will find use primarily for detection of orphan sources in scrap metal which are found much more frequently than the deliberate trafficking of fissile material.

In 2007, a national exercise called ‘Adriatic Gate’ was carried out simulating the discovery of orphan sources which then escalated to a ‘dirty bomb’. The exercise required the Cooperation between various national agencies and harmonized (and rapid) response. International observers from numerous countries in the region and from USA took part in the exercise.

6. OTHER INTERNATIONAL COOPERATION

In order to prevent illicit trafficking with nuclear and radioactive material a number of actions have been organised primarily through international organizations such as the IAEA and the European Commission (e.g. regional and inter-regional training courses for ‘front-line officers’, regulators and intelligence).

UNECE (United Nations Economic Commission for Europe) published Recommendations in 2006 that can be used as a useful guide for scrap metal yards, metal smelters, customs, regulatory authorities and transporters, amongst others. The aim of the Recommendations is to prevent incidents and to provide adequate response in case of incidents.

At end of 2006, regional Cooperation in the area of detection of orphan sources in scrap metal was intensified between the former Yugoslav republics. Two expert meetings were held in 2007 in Zagreb (Croatia) and in Beograd (Serbia). A list of contact points was established and it was agreed to exchange information by e-mail in the event of sources being discovered. Further cooperation may involve the signature of a Memorandum of Understanding, establishment of list of border crossings to be equipped with portal monitors, the issue of working procedures for the group, etc. The IAEA has identified this type of regional cooperation as being unique in comparison with other regions of the world.

7. CONCLUSIONS

Slovenian authorities have implemented several regulatory and law enforcement measures in order to prevent accidents involving radioactive materials in scrap metal. Some of the border crossings have been equipped with portal monitors to check shipments. Customs and police officers have been provided with pagers and hand-held radiation detection devices. The majority of scrap metal recyclers and facilities of the metallurgical industry are equipped with portal monitors and hand-held radiation detection devices.

The Decree on checking shipments of metal scrap for radioactivity, which entered into force in 2008, requires that every importer presents to the customs written evidence of radiation measurements before any shipment of scrap metal can be brought into Slovenia. Such radiation measurements can be performed only by certified organizations. The decree addresses also shipments of scrap metal from EU countries and domestic shipments (partially) as well as those in transit. The decree has contributed to a better control over inadvertently imported orphan sources in scrap metal from abroad as well as to a tighter control of inner trade.

A good and goal-oriented cooperation has been established between different Slovenian organizations, with neighbouring countries and with different international organizations so as to efficiently deal with contaminated scrap. At the end of 2006, regional cooperation in the area of detection of orphan sources in scrap metal was intensified between the former Yugoslav republics.

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MONITORING OF SCRAP METAL — EXPERIENCE WITH RADIOACTIVE SOURCES AND ACTIVATION/FISSION PRODUCTS

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Abstract

This paper presents an overview of the possibilities for detecting radioactive material in metal scrap from various origins by means of radiation portal monitors, of the procedures that are usually followed when a radiation alarm is triggered and of the viewpoints of the nuclear industry on clearance and of the scrap industry on receiving cleared material.

1. INTRODUCTION

Metal scrap is a valuable material which plays an important role in modern industry. Extensive measures have therefore been taken to ensure the quality of the scrap and the new metal that is manufactured from it. Product quality is one of the main reasons why the metal processing industry has reacted vigorously to the detection of radioactive materials of various origins in scrap.

The first reports of radiation sources mixed in scrap loads and naturally occurring radioactive material (NORM) as contamination on scrap metal surfaces were published in the early 1980s [1]. In the 1980s and 90s, there were an increasing number of reports on the subject, partly due to the fact that people became more aware of the possibility of radioactive materials being in scrap and of its dangers and partly due to the fact that more measuring devices had been installed. More recently, there has been a tendency towards a decrease in the number of occurrences as a result of measures being widely implemented to prevent radioactivity from entering the scrap at the place of origin.

There are two main types of radioactive material which can enter metal scrap:

- Radiation sources, e.g. sources contained in technical or medical instruments that are not removed when the device is scrapped;
- Contamination in the form of scale or ‘crud’ on the inner surfaces of pipes and large vessels or containers originating from the oil and gas industries.

There are a number of other origins, ranging from surface contamination due to Chernobyl fallout to radioactive material imported from various countries.

In order to avoid such contamination entering scrapyards, foundries, steelworks or landfills, such facilities — at least the larger ones — have equipped their entrance gates with sensitive monitors that aim to detect gamma emitting radionuclides in the scrap or waste loads of lorries or freight trains, thus preventing the radioactive material from entering the site. Similar precautions have been installed at many harbours, e.g. at the unloader or at the entrance gate of the harbour area, so that ship loads can also be monitored. In Germany, for example, there are now many measurement facilities at foundries and scrapyards as well as at selected border crossings. This type of equipment is usually called a 'radiation portal monitor' or RPM.

While these detectors are very sensitive to changes in radiation dose rate, the residual activity on material that was cleared from nuclear installations using clearance levels as proposed by the European Commission (EC) [2, 3], the IAEA [4] or by the United States Nuclear Regulatory Commission (USNRC) [5], is usually not among the material that can be detected. This paper gives an overview of the possibilities of detecting scrap containing radioactive material from various origins in radiation portal monitors, of the procedures that are usually followed when a radiation alarm is triggered and of the viewpoints of the nuclear industry on clearance and of the scrap industry on receiving cleared material.

2. PRECAUTIONS BY THE SCRAP METAL INDUSTRY, EQUIPMENT

2.1. How radioactive materials enter scrap

There are various ways by which radioactive materials can enter scrap. Two main types of radioactive material can be distinguished:

— Radioactive materials of natural origin;
— Radioactive materials of artificial origin.

These two types have to be well distinguished when devising strategies for detection.

2.2. Natural sources

Natural radioactive material has always been a part of our environment, dating from the formation of matter itself. Because of the long half-lives of the associated radionuclides, this radioactive material has not vanished yet. The most important nuclides are those of the decay chains of uranium-238, uranium-235 and thorium-232 as well as potassium-40.

Natural radionuclides can be found in soil, in water and in air in varying concentrations. There are processes that lead to their accumulation on, e.g. metallic surfaces. Scrap with radioactive contamination of natural origin is usually grouped under the heading ‘NORM’ (naturally occurring radioactive material). Such material may arise mainly from:

— The dismantling or refurbishment of facilities of the uranium mining and milling industry;
— Coal mining, e.g. from facilities for mine drainage;
— Prospecting, extraction and milling of ore and fossil fuels (oil, gas, ores like those of aluminium, copper, zinc, lead, tin, and the rare earths);
— Water treatment facilities;
— Industrial products (welding electrodes, parts of jet engines, incandescent mantles, moulding sands containing zirconium and monazite);
— Construction materials (slate, gypsum, granite, bauxite);
— The paper industry,
— The optical industry (polishing powder, thoriated glass);
— Sludges from water treatment;
— Refractory material;
— The chemical industry;
— Power stations and combustors (ashes, slags, dust, etc.);
— Phosphate production (production and application of phosphate fertiliser).

2.3. Artificial sources

A large number of artificial radionuclides may be present on or in scrap, among which cobalt-60 and caesium-137 are the most important ones; especially in terms of abundance and possible associated dose rates. The origins of such radionuclides, however, may have an even larger variation than those of NORM, since they are present in a large variety of appliances and may easily enter the scrap if dismantling operations are carried out carelessly. The following list gives an idea of the main origins:

— Industrial sources for measuring thickness or density;
— Industrial sources for radiography, e.g. for the inspection of welds;
— Medical sources, e.g. for radiotherapy;
— Sources used for a large variety of applications in research and development;

FIG. 1. Examples of NORM: incrustation in water pipes, scales in pipes from mining (from [6]).

— Contaminated or activated scrap from the illicit removal of material or devices from nuclear installations;
— Cleared material, where the residual contamination or activation is below legally prescribed clearance levels.

Radioactive sources bear the highest risk potential, as they are often found in scrap without their shielding or with broken safety appliances. High activity sources can pose serious risks to personnel and can threaten the operations of steelworks or foundries, as they could contaminate an entire plant, causing substantial financial costs. Figure 2 shows examples of sources found among scrap.

FIG. 2. Caesium-137 source (165 MBq) in a depth gauge and caesium-137 source (65 MBq) in a thickness gauge (from [6]).

2.4. Localization of the activity

The radionuclides and amounts of radioactivity involved can vary considerably. One obvious but very important difference is the spatial distribution of the activity:

— In the case of radiation sources, the activity is localized in a very small area. The activities may be in the MBq or GBq range, but even very large sources with activities of TBq up to 10 TBq have been found (or even melted down) on a few occasions in various countries. The activity in a radiation source can usually not be dispersed (prior to the melting process) which leaves only external irradiation as the relevant radiological pathway.

— In cases where the radioactivity is present as surface contamination it is much less localized. The contamination may be released into the air by handling the material making inhalation a possible radiological pathway. Although the ‘total’ activity of the contamination may be high, the ‘specific’ activity is much lower than in the case of radiation sources.

Only a limited number of radionuclides have been found in scrap in Germany. In the case of radiation sources, the most important nuclides are cobalt-60, caesium-137, radium- 226 and strontium-90. Where NORM contamination is present, varying amounts of the nuclides of the uranium and thorium decay chains are found.

2.5. Measurement equipment

Today, stationary measurement equipment for radiation portal monitors (RPM) usually consists of large area scintillation counters that can detect particle radiation as well as photons and neutrons. For use in radiation portal monitors, the equipment is optimised for the detection of gamma radiation by choosing a suitable scintillator medium with high electron density and an appropriate geometry.

Spectrometric measurements are used only in a small percentage of detectors. These devices have the advantage of being able to detect the presence of certain key nuclides, which helps in the discrimination between artificial nuclides, like cobalt-60 and caesium-137, and radionuclides of natural origin.

Many commercial suppliers offer equipment ranging from hand-held detectors to fully automated stationary facilities. Therefore, only the operation principle of the measurement equipment is described here, without reference to specific devices.

Measurements are used to detect whether (detectable) activity is present in the scrap load and — if energy discrimination or spectrometric measurements are used — whether certain nuclides are present. It is not possible to determine the amount of the activity itself, as the geometrical conditions and the shielding are not known. Examples of the dependence of detectable activities on the geometrical conditions and shielding are described below.

The measurements are carried out to detect the presence of gamma emitting radionuclides by detection of statistically significant variations of dose rate above the variations of background count rate. This triggers an alarm and thus establishes the first hint of the presence of activity in the scrap load. The background count rate is continuously measured and averaged when no vehicle is

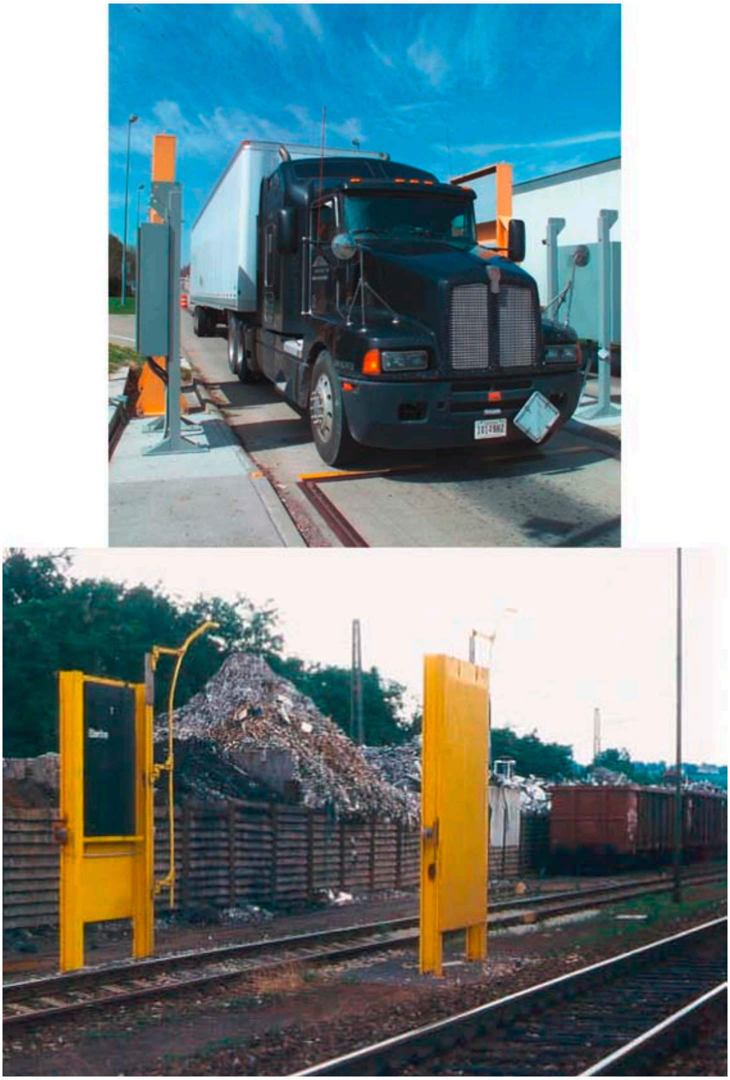

FIG. 3. Truck weigh and inspection station with RPM in the USA (left) [7] and RPM at a rail track of a scrapyard in Germany (right) [6].

present between the detectors. The measurement itself takes place while the lorry or freight car passes through the detector. The presence of the vehicle is registered e.g. by light detectors. During measurement, the speed of the vehicle must not exceed a certain value in order to allow appropriate detection limits to be reached (usually walking pace or a few km/h). In contrast to carrying out only one or two static measurements, dynamic measurements along the whole conveyance ensure that the whole load is monitored and the approximate position of a radioactive source or of the contamination can be estimated, if an alarm is triggered.

Radiation portal monitors with plastic scintillator monitors are capable of detecting statistically significant increases of dose rate of about 5 nSv/h above background. Sensitivity can be increased by setting energy windows, i.e. the energy ranges from which incoming photons are counted, to appropriate values, so that only the radiation from certain radionuclides, like cobalt-60, caesium-137 or naturally occurring radionuclides, is detected. This, however, decreases the effective overall count rate.

The demands that the measurement process has to meet are best described by the schematic diagrams in Fig. 4, showing the background count rate and the alarm level over time, both with an empty conveyance (little shielding, caused only by the side panels of the lorry or freight car), and with a fully loaded conveyance (maximum shielding by the scrap load), during passage of the conveyance between the detectors.

The measurement equipment has to cope with these highly variable shielding conditions, and also has to screen out any interference from transitional variation of background count rate because of other reasons. The lower limit of detection of the entry measuring devices can be as low as ~5 nSv/h (dose rate increase above background at the detector), which is achieved by advanced hardware and software. This detection limit corresponds to the detection of a cobalt-60 point source of about 7 MBq buried in the middle of the scrap load or of only about 15 kBq if the source is close to the surface of the load. Other examples can be found in Table 1 together with Fig. 5. However, in real situations, the detection limit is usually set to a higher level than 5 nSv/h in order to avoid false alarms.

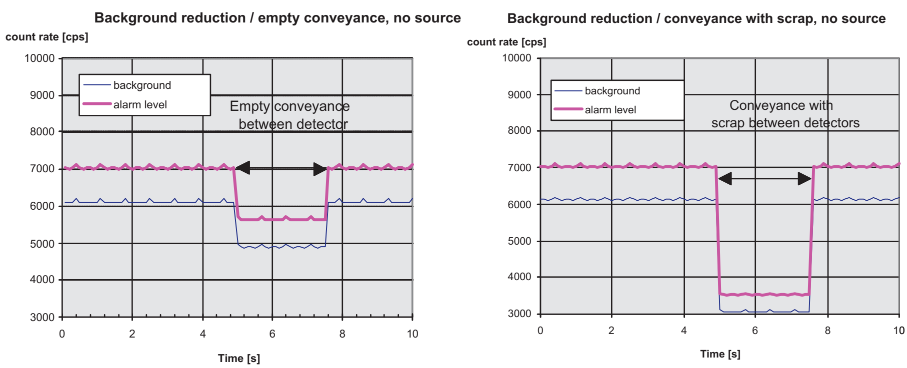

FIG. 4. Background count rate reduction by vehicle without and with scrap load, no source [8].

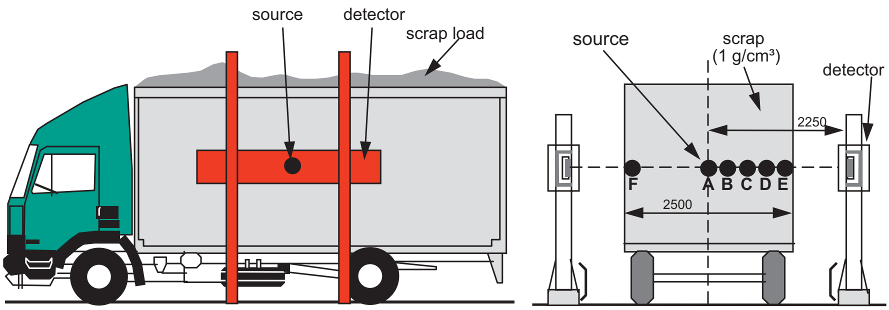

FIG. 5. Positions of point sources (corresponding to Table 1) [8].

TABLE 1. ACTIVITY OF A RADIATION SOURCE THAT CAN BE DETECTED WITH A DETECTION LIMIT OF 5 nSv/h AT THE PLACE OF THE DETECTOR (GEOMETRY AND POSITIONS A–F SEE FIG. 5, EFFECTIVE SCRAP DENSITY 1 g/cm³) [8]

Position of the source	Shielding by scrap [cm]	Activity of the point source [Bq]			
		Co-60	Cs-137	Ir-192	Ra-226
A	125 (mid)	6.5E+06	1.5E+08	5.5E+08	9.7E+13
B	95	1.4E+06	1.9E+07	5.1E+07	1.9E+12
C	65	2.8E+05	2.4E+06	4.6E+06	2.8E+10
D	35	6.5E+04	3.4E+05	4.2E+05	4.0E+08
E	5	1.7E+04	6.6E+04	4.9E+04	8.3E+06
F	1	1.5E+04	5.7E+04	4.2E+04	5.9E+06

It can be seen that the activity that can be (theoretically) detected depends to a large extent on the radionuclide (i.e. the gamma energies) and the position inside the load. The dependence on the effective scrap density is shown in Table 2. It can be seen that densely packed scrap will make large cobalt-60 sources undetectable, while radium-226 sources cannot be detected in the centre of the scrap load even at low densities.

These examples also illustrate the limited use of spectroscopic systems, i.e. those that discriminate certain energy ranges. The count rate necessary to achieve a sufficiently low detection limit increases for scrap loads with higher densities, and a distinction between a radium-226 source and ‘real’ NORM is not possible. The only advantage of such systems is that a positive identification of cobalt-60 or caesium-137 will lead to appropriate caution when searching for the activity.

TABLE 2. ACTIVITY OF A RADIATION SOURCE IN THE CENTRE OF THE LOAD THAT CAN BE DETECTED WITH A DETECTION LIMIT OF 5 nSv/h AT THE POSITION OF THE DETECTOR FOR VARIOUS EFFECTIVE SCRAP DENSITIES [8]

Scrap density ρ [g/cm³]	Activity of the point source [Bq]			
	Co-60	Cs-137	Ir-192	Ra-226
0.5	5.0E+05	3.9E+06	7.2E+06	3.8E+10
1.0	6.5E+06	1.5E+08	5.5E+08	9.7E+13
1.5	1.0E+08	7.9E+09	4.2E+10	6.9E+16
2	2.1E+09	4.8E+11	3.0E+12	3.3E+19
3	8.5E+11	2.2E+15	1.1E+16	8.8E+24

This short survey on the requirements for radiation portal monitors can be summarized as follows:

- — Robustness, high reliability, easy operation;
- — Low detection limit, i.e. optimization for gross gamma counting;
- — Low error rate (avoidance of false alarms);
- — If spectrometric systems are used: variable adjustment of the region of interest to distinguish between NORM and artificial sources.

3. HOW TO PROCEED WHEN RADIOACTIVITY IS DETECTED

3.1. General considerations

In many countries there is no general procedure to be followed when a radiation alarm occurs. Each foundry, scrapyard or waste management facility may have different approaches for responding to alarms and different action levels and capabilities and measurement equipment. In addition, radiation portal monitors for vehicles, while similar in principle, have different features, detection limits and capabilities. Also, foundries, scrapyards or waste management facilities receive their materials or waste from different sources; some are more likely to receive radioactive medical waste. These aspects have to be kept in mind when procedures are recommended on how to proceed when a radiation alarm occurs. This section describes an approach that could be followed in the case of an alarm.

When activity is detected in a load, several options exist, ranging from sending the scrap back to the sender to careful unloading and separating the load with the aim of localising and removing the contamination. The most common approach is to prevent the suspicious scrap load from entering the premises and to direct the lorry to a place where the material can be safely inspected. At the same time, the incident is reported to the competent authorities (in addition, details are usually also transmitted to other foundries or scrapyards in the vicinity in order to prevent the lorry driver from trying to get rid of his scrap elsewhere). In many cases, the authorities decide to investigate the load prior to sending it back. A decision on how to proceed from the time from when the lorry has been secured depends on the measured dose rate, the visual inspection of the scrap, considerations of the cargo documents etc. and on the advice of experts that may be called in by the authorities or the facility where the alarm has occurred.

It is obvious that the way to proceed in the case of an alarm depends on the risk potential, which is very often associated with the dose rate. As already mentioned, a low dose rate does not guarantee a low activity, as the source may be buried deep inside the scrap. However, a low dose rate allows safe inspection of the scrap and eventually unloading to determine the origin of radiation. If the dose rate is found to increase in such a case, the personnel can still safely back out. In such a case, the recovery of the source has to be done by a specialised team using additional shielding measures and a suitable transport container.

3.2. Studies on the radiological consequences

In order to avoid unnecessary deployment of radiation specialists and special equipment, a number of studies on the radiological consequences of radioactivity in metal scrap have been conducted, and procedures have been developed on how to proceed depending on the measured dose rate.

A procedure which is widely followed in Germany has been developed in the study [8]. Radiological scenarios have been devised on the basis of the actual procedures followed by the industry and the authorities for the following situations or workplaces: loading and transport of the scrap, unloading after an alarm of the radiation portal monitor, separating the scrap load for identification of the source, removal and disposal of the source. In addition, the following situations have been investigated, assuming that the radioactivity would remain undetected and would therefore not be removed: scrapyard (storage, handling, segmenting), foundry, product manufacturing, use of products and by-products, other uses.

A realistic dose assessment carried out in [8] showed that the probability of individual doses in the range of mSv or 10 mSv (per incident) is rather small, but it is not zero. However, it can be expected that in the majority of cases individual effective doses will not exceed the range of a few μSv to several 10 μSv. The following persons are likely to receive the highest doses: the driver of the lorry (in the case of train or ship transport there is almost no risk to the train driver or to the personnel on board the ship) and the persons that unload the scrap. In cases where radiation sources pass without detection, the personnel at scrapyards or foundries coming into close contact or even separating the scrap manually can likewise receive high doses. This underlines the radiological relevance of the problem of hidden radioactivity in scrap.

This short discussion also reveals that a hidden radiation source is much more dangerous than broadly distributed contamination on the surfaces of the scrap, even if inhalation of resuspended contamination is taken into account. Large radiation sources that remain undetected and are handled without knowledge or carelessly, have the potential to kill people. If a large radiation source reaches a foundry and is melted, its activity is either homogeneously distributed in the product metal (cobalt-60, iridium-192 and other radionuclides) or goes to the slag or filters (caesium-137). Radionuclides from NORM are mainly transferred to the slag in the melting process. In any case, the specific activity is drastically reduced which also reduces the overall radiological hazard, but such an incident can still lead to large scale contamination in products thereby irradiating people or to large scale contamination in metal plants. The cost of the removal of the activity can be extremely high and can sometimes cause financial disaster for a company.

The continuous increase in the number and sensitivity of measuring devices also leads to an increase in the probability that traces of NORM will be detected in scrap loads. Because each detection of radioactivity means unnecessary costs and great efforts to localize and remove the contamination, it is important to avoid these incidents as reliably as possible.

Based on these radiological considerations, the following approach was developed in the study [8]:

- If the dose rate does not exceed 5 μSv/h: Workers may approach the vehicle and investigate the scrap. Visible inspection may lead to the conclusion that the dose rate is caused by NORM, in which case melting of the scrap could take place. Prolonged exposure should, however, be avoided.
- If the dose rate exceeds 5 μSv/h: In order to assure protection of the workers, radiation protection specialists should be brought in.
- If the dose rate exceeds 100 μSv/h: In this case, all work in the vicinity of the vehicle should be immediately stopped, and a barrier at a dose rate of about 5 μSv/h should be set up. Any further approach may only be made by radiation protection specialists. The authorities have to be called in.

Such a procedure, allowing the scrap dealer, foundry, etc. to proceed with only slightly contaminated scrap at their own discretion, is widely applied and limits the expensive involvement of the authorities to those cases where supervision is really needed. In some countries, lower action levels; e.g. 0.1 μSv/h, are used for triggering notification of the authorities.

3.3. Approach of scrap dealers

Scrap dealers, foundries, etc. include special clauses in their contracts for cases when radioactivity is detected in metal scrap. Usually, delivery of scrap with radioactive material in or on it obliges the vendor to pay compensation for all loss and expenses caused by this incident. In addition, there may be claims because of neglecting the legal duty to maintain safety, and the vendor may also be held criminally liable. A return of the scrap is usually prohibited, unless the material has been carefully investigated and radiologically assessed.

A requirement of reporting the incident to the competent authority usually only exists if the exemption values as laid down in the Basic Safety Standards [9] are exceeded. This, however, requires an investigation of nuclides and their activities.

3.4. Practical application of the procedures

The following sequence of events is taken from a recommendation of Deutsche Bahn to customers receiving scrap loads via freight cars [6].

(a) The radiation portal monitor (on the premises of a scrapyard, steelwork, foundry, landfill etc.) sounds an alarm.

(b) It is ascertained that this is a real alarm by passing the lorry or freight car through the detectors several times.
An alarm does not necessarily mean that activity above relevant legal limits has been detected. An alarm *per se* need not be reported to the authorities.

(c) The detection of radioactivity is made certain by additional dose rate measurements on the outside of the conveyance.
In this way, a first estimation of the risk potential may be gained: high dose rate means high activity and therefore high risk, low dose rate means no risk from staying near the conveyance, but does not tell anything about the activity, as this may be heavily shielded and may be positioned in the middle of the scrap load.

(d) Transport of the conveyance to a place nearby which is suitable for separating the scrap.
The conveyance may be moved to a place suitable for separation without special permit. It may not be sent back to the place of origin without making sure that no activity above exemption values is present in the scrap.

(e) Separation, measurement and determination of the relevant radionuclides, securing the material by radiation protection experts.
The radionuclides and their specific activities are determined. It can thus be decided whether the material complies with exemption values and may therefore be handled without appropriate permit or licence. The conveyance is measured to determine whether the relevant limits of the transport regulations are complied with.
(f) Final result and decision how to proceed.

3.5. Special considerations at borders

With the increased awareness of potential terrorist attacks today, radiation portal monitors at borders have to fulfil not only the duty to detect large radiation sources, but also fissile materials like uranium or plutonium. Therefore, the monitors are optimized to detect photons and neutrons. As fissile material is, however, out of the scope of this paper, these types of detectors are not described here.

An alarm at a radiation portal monitor at a border will usually lead to refusal of entrance into the country. The following procedure for the Canadian/US border describes this in short, while Fig. 6 shows an example of a monitor configuration at a US border station.

FIG. 6. Example of a monitor configuration at a US border station [10].

"Waste loads which have been identified to contain radioactive materials may be refused entry into the land fill, transfer point, scrapyard, etc. If alarms identify radioactive material in a load at the Canadian/US border, it will most likely be rejected entry into the USA. In these cases, the load will have to be transported to anther location. Due to the difficulties with meeting the Transport Regulations in such instances, an estoppel has been introduced for use by the Canadian Nuclear Safety Commission (CNSC) inspectors. The CNSC inspector can provide the form to the requestor who will then complete the form. The CNSC inspector will review the completed form. If approved, the form will be returned to the requestor, as the carrier will require the signed document for transport." [10]

Measurements at borders are also common in Europe. For these, dose rate measurements are usually optimized for the higher vehicle speeds in comparison to entrance gates at landfills, scrapyards, foundries, etc.

4. CONSIDERATIONS OF THE SCRAP INDUSTRY AND STEEL MANUFACTURERS

The scrap industry and steel manufacturers wish to prevent radioactivity of any origin from entering the steel pool. This pertains to cleared metal scrap from nuclear installations as well as to radioactive sources. The general tendency is to count anything as radioactive that can be detected by the entrance monitors at scrapyards, landfills or foundries. In addition, it is a general custom in the metal industry to agree in contracts that radioactivity in a scrap load constitutes a fault and gives the buyer the right to reject the scrap. Usually, the consignor has to bear the costs for locating and removing the source of radioactivity or for sending back the load.

The result of such arrangements is clear: no distinction is made about the origin of the activity, i.e., whether it constitutes no harm because the material has been cleared and is regarded as non-radioactive in a legal sense or originates from NORM industry and is below appropriate exemption values, or whether the radioactivity is localized in a radioactive source. This means that the interests of the scrap industry and steel manufacturers are often diametrically opposed to those of the nuclear industry, as discussed in the next section. It also means that sufficiently small amounts of gamma emitting radionuclides that are not detected by entrance monitors (or even large amounts of beta or alpha emitting radionuclides which cannot be detected at all) are not regarded as radioactivity by the scrap industry.

In Germany, for example, the steel industry opposes the use of radioactively contaminated scrap, even cleared scrap from nuclear installations, as this is supposed to lead to high damage in the steel mills, both because of the physical effects of high activity present in the scrap and eventually in the products, and because of the loss in reputation for a plant that has sold contaminated material. This is the reason why the vendor generally has to accept a clause like the following:

> "… we guarantee that we will deliver only such scrap that has been monitored with our own measurement equipment to be free of ionising radiation. Therefore, we … can declare to the best of our knowledge that on the basis of the aforementioned measurements, the scrap will be free of ionising radiation above ambient background radiation."

The last part of the clause shows exactly the problem: the certification of absence of radioactivity is linked to the absence of dose rate above background levels. This leads to the following problems:

— The background dose rate may not be the same at the place of the vendor and at the place of the buyer. Furthermore, the measurement equipment may not be the same or may not be set to equal levels. This may lead to different interpretation of dose rates from the same scrap load.
— A scrap load with cleared material from nuclear installations will usually not trigger the entrance alarm, as is discussed in the following section. Such a load would therefore be interpreted as non-radioactive. Nevertheless, the scrap and steel industry opposes clearance per se.
— Changes in the configuration of the load by the movements of the vehicle during transport may lead to changes in the external dose rate. Cases have been reported where an exit monitor at one facility did not detect an increase in dose rate above background, while the entrance monitor at the recipient produced an alarm.

These points show the weakness in the concept of linking the presence of radioactivity to the dose rate alone. In real life, however, visual inspection of the load, knowledge of the origin of the material etc. will also help to identify potentially contaminated material.

5. CONSIDERATIONS OF THE NUCLEAR INDUSTRY

5.1. General considerations

Clearance of material is an essential part of material management within the nuclear industry, in particular during decommissioning of nuclear installations. In order to meet clearance levels, the material is — as far as necessary — decontaminated. However, on a certain part of the metallic surfaces, some radioactivity will remain. For reasons of the measurement process and other conditions in the clearance procedure, such material will usually be under the clearance levels. It is likely that the residual activity on a load of cleared scrap will be in the range 10% up to several 10% of the clearance levels on the average, while a single load of course may reach higher levels.

5.2. Scheme of clearance values for metal scrap

Clearance levels have been established in many countries worldwide and international studies have been carried out on clearance comparing the various approaches [11]. There are a small number of recommendations on the clearance of scrap, which have been issued by international bodies and organizations, in particular:

— European Union: Recommendation RP 122 part I [2] on general clearance, as well as RP 89 [3] on clearance of metal scrap;
— IAEA: Safety Guide RS-G-1.7, Application of the Concepts of Exclusion, Exemption and Clearance [4], which is valid for all types of materials.

An overview of clearance levels for some important radionuclides are given in Table 3. Clearance levels for building rubble have also been included for gamma emitting radionuclides; the scenarios covering large quantities of rubble are not dissimilar to those of metal scrap. It can be seen that unconditional clearance levels, i.e. those for large amounts of material regardless of its destination after clearance, are generally on the order of 0.1 Bq/g for cobalt-60, while clearance levels for clearance of metal scrap for melting only may be one order of magnitude higher (in the studies summarized in Table 3, the values have been rounded to orders of magnitude). As becomes clear from the example in the next section, such values play an important role in the estimation of whether a load with cleared scrap may be detected in a radiation portal monitor.

TABLE 3. OVERVIEW OF CLEARANCE LEVELS FOR SELECTED RADIONUCLIDES (FROM [11])

Purpose	H 3	C 14	Ni 63	Co 60	Cs 137	Sr 90	U 235	Am 241	Pu 239	Unit
Unconditional clearance, RP 122/I [2]	100	10	100	0.1	1	1	1	0.1	0.1	Bq/g
Unconditional clearance, RS-G-1.7 [4]	100	1	100	0.1	0.1	1	—	0.1	0.1	Bq/g
Metal scrap for recycling or reuse, RP 89 [3]	1,000	100	10,000	1	1	10	1	1	1	Bq/g
Building rubble, RP 113 [12]	100	10	1,000	0.1	1	1	1	0.1	0.1	Bq/g

5.3. Detection of activity in cleared metal scrap

The question whether activity below clearance levels can be detected in a load of scrap can generally be answered as follows:

— Activity below unconditional clearance levels that is more or less homogeneously distributed in a normal scrap load cannot be detected by normal radiation portal monitors, as is outlined in the following example;
— Metal scrap with a residual activity that exceeds clearance levels for metal scrap for melting, on the other hand, could cause an alarm, depending on the settings of the radiation portal monitor, and might therefore be rejected.

Example: Consider a scrap load of an effective density of 1.5 Mg/m^3 and a contamination consisting only of cobalt-60. These are conservative assumptions, as a scrap load of higher density would lead to higher self-absorption and the presence of other radionuclides would decrease the relative contents of cobalt-60 which is a strong gamma emitter and can therefore easily be detected. The scrap load is supposed to have a geometry of 2 m width, 5 m length and 2 m height, equalling 20 m^3 or 30 Mg. A clearance level of 0.1 Bq/g is assumed. Then if the average activity concentration of the load was at the clearance level, this would cause an activity of 3 MBq in the scrap load. A shielding of 0.5 cm inactive material from the lorry is assumed. This would cause a dose rate of roughly 10 nGy/h at 50 cm distance (calculated by MicroShield). This value could be detected in principle by radiation portal monitors, but usually the detection limit is set to higher values in order to avoid false alarms. If the material is contaminated with a residual activity of only 30% of the clearance levels, the resulting dose rate could not be detected at all by such monitors.

It follows that the use of unconditional clearance levels on the order of 0.1 Bq/g for Cobalt-60, which are in use in many countries and have also been recommended by the European Commission and the IAEA, would not cause any problems for trade of metal scrap. The use of significantly higher clearance levels, however, might lead to detection in radiation protection monitors and therefore requires prior coordination between the vendor and the receiver of such material.

5.4. Willingness to accept cleared material

The question remains as to whether the steel industry or the scrap market in general is willing to accept cleared material from nuclear installations. The absence of an alarm from a radiation portal monitor may be interpreted as absence of activity of any concern, but if a scrap load originates from a nuclear installation, scrap dealers may still be uneasy about whether there might be undetectable activity, or whether it is good for the business if the customer, e.g. a steelworks, knows that the scrap dealer is making business with a nuclear installation. Therefore, there is reluctance in the metal industry to accept material of such origin.

However, some scrap dealers recognise the high quality of material from the nuclear industry, especially from the decommissioning of nuclear power plants. They know that they can get well cleaned high quality steel of various grades from a reliable source. For this reason, in Germany a small number of scrapyards accept material from nuclear power plants that has been cleared — even using the higher clearance levels relevant for the melting of metal scrap. Use of this clearance option saves the nuclear power plant a considerable amount of effort in demonstrating that the clearance levels are complied with, as the higher values allow shorter measurement times and less effort for producing documentation. The use of these values does not necessarily mean that more activity is cleared.

6. CONCLUSIONS

Radiation portal monitors at the entrance gates of scrapyards, steelworks, foundries, etc. are capable of preventing dangerous radioactive materials from entering the facilities, avoiding harm to workers as well as to the general public and averting possible financial disaster for the facilities. These monitors are reliable and can detect sufficiently low activities of gamma emitting nuclides even in the larger scrap loads. Various types of equipment are on the market and they are operated with differences in settings, in detection limits and in other characteristic features. The metal industry generally considers a scrap load to contain radioactivity if the radiation portal monitor produces an alarm, which is based on an increase in radiation dose rate above background, and accepts material when no measurable increase in dose rate is detected. This is usually part of standard contracts.

A general reluctance exists among scrap dealers and the metal industry to accept metal scrap that has been cleared from nuclear installations, even though such material will not trigger an alarm if — as is usually the case — unconditional or general clearance levels have been used. Some scrap dealers, however, have recognized the high quality of scrap of nuclear origin, especially from the decommissioning of nuclear power plants, and regard this material as a valuable resource.

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PROBLEMS RELATED TO ORPHAN RADIOACTIVE SOURCES IN SCRAP METAL

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Abstract

Georgia is a small country situated between the Black and Caspian Seas. Taking into consideration the country's geo-political situation; special attention is paid to radiation monitoring of scrap metal at Georgian borders. The established border check framework gives the possibility to avoid any illegal transfer of radioactive source. The special activity for training of staff of scrap metal dealing facilities is ongoing. New legislation supporting this activity is discussed.

1. INTRODUCTION

Georgia had received hard heritage from the former Soviet Union for radiation protection. A great number of so calledorphan radioactive sources were left on Georgian territory. (More than 300 orphan radioactive sources were found and recovered by Georgian specialists. These sources are mainly of military origin. After withdrawal of the former Soviet military troops, they were left on military bases and disseminated from there. A number of orphan radioactive sources are also of civilian origin, when during state control interruption many enterprises stopped their activities or changed their profile. It is notable, that when the first major accident with orphan radioactive sources happened at Lilo military base, some ^{137}Cs sources were found in scrap metal [1]. These sources can be easily disseminated within the scrap metal or as scrap themselves. Many sources were found in special containers assigned as scrap metal (Fig. 1).

Georgia has only one great factory proceeding with metals — Rustavi Metallurgical Plant has a special unit for radiation protection, but taking into account some commercial problems, the plant has yet to start working. Meanwhile, it has to be considered that Georgia is a transit country and many goods cross its territory. The fact that some of the neighboring countries widely use nuclear and radioactive materials increases the likelihood of illicit trafficking of such materials within scrap metal. Another factor of concern is represented by

FIG. 1. A typical container with caesium-137 source found on a former Soviet military base in Georgia.

the orphan radioactive sources. Therefore, Georgia pays special attention to check all scrap metal inside the country as at its borders.

2. LEGISLATION AND REGULATORY INFRASTRUCTURE

The radiation safety system in Georgia is based on the framework legislation — the Law of Georgia No. 1674-IS On Nuclear and Radiation Security — which went into force on January 1, 1999. This law (Article 8, Paragraph 1) designates the Ministry of Environment and Natural Resources Protection of Georgia (MENRP) a national regulatory body in the field of nuclear and radioactive activities and with this purpose the Nuclear and Radiation Safety Service (NRSS) is set-up within the MENRP (Article 8, Paragraph 2). The export and import control of radioactive sources is regulated by the special system of licenses and permits, which is based on the framework legislation — the Law of Georgia No.1775-RS on Licenses and Permits – adopted on June 24, 2005. Every act of import and export of non exempted (or cleared) source must be approved by the special permit issued by the MENRP. Such a permit is based on the conclusion of the NRSS. Main regulatory norms are defined by national basic safety standard – RSL-2000. It should be emphasized, that the text of Frame Law and national standards are quite old and need sufficient revision to meet international standards and requirements. In close collaboration with the EU and IAEA experts, the new version of the Frame Law and national standards were elaborated. New amended legislative documents consider all basic international requirements, particularly for control of scrap metal, that “every state should encourage bodies and persons likely to encounter orphan sources during the course of their operations (such as scrap metal recyclers and customs posts) to implement appropriate monitoring programmes to detect such sources.” [2]. So, new regulations set requirements to encourage the larger scrap metal dealers to purchase and install radiation detection equipment. It is also very important to provide awareness training to all scrap metal dealers so they can recognize the radiation trefoil and typical containers/housings of radioactive sources. Taking into account the real situation in the country, great attention is paid to the movement of scrap metal through the borders of Georgia to avoid illegal movement of radioactive sources into scrap. RB conducts periodical checking of comparably large amount of scrap metal collected in Georgia. The main Georgian border check points are equipped with radiation detection systems with the possibility to find radioactive sources in scrap metal.

3. SCRAP METAL MONITORING AT GEORGIAN BORDERS

Taking into account that Georgia is transit country and that neighboring countries have nuclear and radioactive enterprises, special attention is paid to check scrap metal at Georgian borders. To prevent illegal movement of any radioactive sources through Georgian borders, the government of the country in close collaboration to US DoE and IAEA conducts special activity considering covering the following tasks:

- Establish of radiation checking portal monitors at Georgian border check points;
- Equip Georgian border guards and customers with handle detectors and spectrometers to find, locate and identify radioactive sources;
- Train border guards and customers to operate radiation detection system;
- Establish special framework for to quick response on every emergency situation on borders.

According to planned activity, many Georgian border check points are already equipped with special portal monitors easily possible to detect gamma and neutron radiation (Fig. 2) and record video information for carriers.

Border guards and customers are equipped with hand-held detectors and spectrometers to conduct secondary investigation of suspected goods. They are properly trained by Georgian specialists. The training materials are based on IAEA-TECDOCS-1311, 1312, 1313 and on case studies of the relevant incidents that took place at the border crossings of Georgia and other countries. To detail

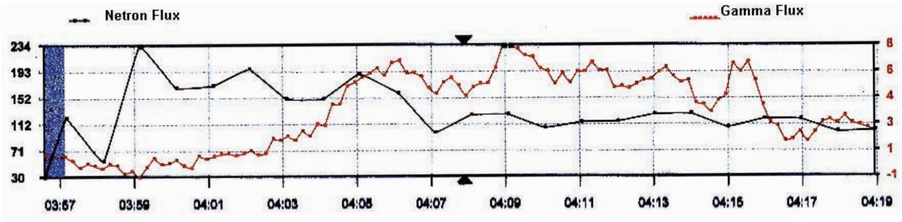

FIG. 2. Printout from the portal monitor showing the distribution of gamma and neutron radiation in the truck passing through the border checkpoint (plotted against the time of the movement on the horizontal axis).

FIG. 3. Plutonium/beryllium source found in the scrap metal shipment at the "Red Bridge" on the Georgia-Azerbaijan border.

every possible action for activity and to check any suspicious good, a special practical guidebook for border guards and customs officials was issued. To establish a framework involving different interested state organizations, the 'Concept of Operation' was elaborated and agreed to among different state bodies. The concept clearly defines the responsibilities and rights of every state organization to check suspected goods and respond to radiological emergency situations at borders.

The best illustrations for the efficiency of an established system are two cases: (a) "Red Bridge" check point (east Georgia) and (b) Batumi naval port (west Georgia), when orphan sources were found in scrap metal. At the first case into scrap metal were fixed two well logging Pu-Be sources (Fig. 3).

FIG. 4. Truck with scrap metal and gun night sights containing ^{226}Ra radioactive sources.

At the second case at Batume naval port, a truck was stopped which was loaded with scrap metal collected in Georgia. Among the scrap was a great number of gun night sights were found. Each of them contained ^{226}Ra source (Fig. 4).

4. CONCLUSION

Georgia pays great attention to conduct radiation monitoring of scrap metal. An established monitoring system helps avoid illegal transfer of radioactive sources out of Georgian borders. The special activity conducts within the country to establish scrap monitoring at re-melting facilities.

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THE ACCUMULATED EXPERIENCE OF THE APPLICATION OF THE SPANISH PROTOCOL AND OTHER NATIONAL INITIATIVES

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Abstract

This paper presents a general overview of the actions taken in Spain to regain control of radioactive sources not subject to the established regulatory control system. The experience gained in Spain through the application of the 'Protocol' for the radiological surveillance of metallic materials (1998–2008) is summarized.

1. INTRODUCTION

In Spain, as in the majority of countries, regulatory control systems are in place to ensure that the use of nuclear and radioactive materials does not cause undue risk to persons or the environment. Specifically, the use of such materials and the transfer of responsibility for them between owners or users require specific authorization. Nevertheless, experience has shown the existence of radioactive materials outside the regulatory control system, even though the controlling authorities are acting efficiently.

The authorities responsible for regulatory control in Spain are the Ministry of Industry, Tourism and Commerce (MITYC) and the Nuclear Safety Council (CSN). For decades they have been taking action in different ways to prevent the existence of uncontrolled materials or to minimize their presence to the maximum possible extent. These actions are complementary to the normal activities of these organizations; which are aimed at continuously improving and strengthening the control system.

Initially, the operational responsibilities for the performance of these activities were assigned to the Nuclear Energy Board (JEN), which subsequently became the Centre for Energy, Environmental and Technological Research (CIEMAT).

ENRESA was established in 1984 to manage the radioactive waste generated by the nuclear facilities in Spain, at present numbering nine reactors, and by medical, research and industrial facilities using radioactive materials, of which some 1300 are currently authorized, 600 of them normally generating radioactive waste. In view of its professional activities over the years in different fields, the human and material resources available to it and its wide experience in the removal, conditioning, characterization, transport and management of nuclear and radioactive materials, the Spanish Authorities in charge of controlling radioactive materials rely on ENRESA for the different campaigns organised to prevent the existence of materials beyond control, as described below, or to minimise them to the extent possible.

2. OVERVIEW OF THE ACTIONS TAKEN TO REGAIN CONTROL OF RADIOACTIVE SOURCES

2.1. Campaigns for the removal of sources of radium (Ra-226)

These campaigns were originally organised in the 1970s by the then Nuclear Energy Board (JEN) (now CIEMAT) and later promoted by the CSN. Since 1986, ENRESA has participated — undertaking the management of the materials collected.

The main objective was the removal of the existing radioactive sources of Ra-226 that were used prior to the middle of the last century in the treatment of cancer by radiotherapy. The wide and dispersed use of these sources, mostly in the private sector, justified their confiscation at no cost to the possessors.

After more than 30 years of such campaigns, several thousand radioactive sources have been collected and they were sent to an authorized specialist management company in Hanford, Washington (USA) (see Fig. 1) for final management. These also included a large number of smaller sources of Ra-226 that had been used in the radioactive headers of lightning rods.

2.2. 2.2.Campaign for the removal of radioactive lightning rod headers

This campaign was carried out by ENRESA starting in 1988, following the decision by national authorities to require the users of this type of lightning rod to either apply for authorization as a controlled installation or make the headers available to a company authorized for their management. This was on the on the understanding that their advantage over conventional lightning rods did not justify their use. Initially the removal entailed an associated cost for the user, but it was later performed free of charge as a result of the Royal Decree 903 /1987.

The campaign is now practically completed; some 22 500 lightning rods have been collected from across the country through a long and complex operation that has required a considerable deployment of human and material resources (see Fig. 2).

The removed headers, containing sources of Am-241, were sent to CIEMAT where the sources were removed. There were also headers containing sources of Sr-90, C-14 and Kr-85 although in much smaller quantities. The disassembled sources of Am-241 were returned to the original supplier, in the UK, for recycling. Some 100 headers are still being collected each year.

2.3. Campaign for the removal of disused teletherapy equipment headers

The aim of this campaign, which was limited in scope and duration, was not strictly to recover radioactive material beyond control; rather it was an essentially a kind of 'preventive action'. High activity radioactive materials that had become 'disused' at their installations and that had consequently become 'vulnerable' from the point of view of safety were removed. Very recently the CSN informative Circular 4/2006 was issued to instruct users in this respect.

Within this campaign, 11 disused items of equipment were removed between 1989 and 1991 (see Fig. 3).

The preferred disposal route consisted of exporting the sources to the country of origin, although this has been complicated in certain cases. New supply contracts include the requirement that the disused equipment be removed and returned to the supplier when replaced.

2.4. Campaign for the search and recovery of orphan radioactive sources

Orphan radioactive sources in Spain are those whose activity is above the exemption level established in the regulations and that are outside the regulatory control established for this type of materials; either because they have never been under such control or because it has been lost for whatever reason.

This campaign has been promoted and funded by the national authorities (MITYC) on the basis of the requirements of Royal Decree 229/2006, with advisory services and control provided by the CSN. The forecast duration of the campaign was initially 2 years (2007–2008) but it has been extended to include 2009; its operation has been assigned to ENRESA.

The campaign is based on the collaboration of various sectors that have historically used radioactive material in different medical, research and industrial applications and on voluntary declaration by possible possessors.

The campaign has received advice from a committee of experts made up of members of the CSN, CIEMAT, MITYC and ENRESA. This has contributed to the compilation of historical information on the uses of radioactive materials in Spain and has made it possible to disseminate information on the campaign to the sectors of greatest interest via all the available media, including direct contacts.

Mention should be made of the support and recognition received from international organizations (notably the IAEA and the US NNSA) with which it has been possible to exchange experiences of similar campaigns carried out in other countries with the same aim.

Up to the end of 2008, a total of 112 sources have been collected and another 20 or so declared. They come from different sectors: medical, research, teaching and industry. According to the IAEA scale, one source belongs to category 3; three belong to category 4; and the rest are category 5 or even exempted courses. Among the sources with the highest levels of activity removed are some of Cs-137, Ra-226, Sr-90 and Am-241. The activity of certain of these sources reached GBq levels, and the total activity already collected and secured is around 100 GBq (see Fig. 4).

2.5. Protocol for the radiological surveillance of metallic materials

This protocol was signed in 1999 at the request of the national authorities. It followed the accidental smelting in 1998 of a source of Cs-137 at a steelyard. Its main features have been presented in Session 2 of this Conference.

The signing parties were all the national authorities involved and the most relevant sectors of the metallic materials recycling industry. It was subsequently signed also by the most relevant trade unions in the sector. Subscribing to the protocol is voluntary and as of December 2008 almost 140 companies had done so; representing the vast majority of relevant companies in the country.

The content of the protocol establishes the detailed commitments of each of the signing parties. It is now fully operative and is often taken as an example for other similar national and international developments.

Since the entry into force of the protocol there have been some 100 detections per year, consisting, for the most part, of scrap containing or being contaminated with radioactive material of natural origin (see Fig. 5). Up to December 2008 there had also been seven events caused by the processing of undetected radioactive sources.

Since the protocol came into force, ENRESA has carried out around 320 actions, including 224 actions to remove both the radioactive materials detected prior to processing, mainly sources of Ra-226, Cs-137 and Co-60, and also the waste arising from the aforementioned incidents (see Fig. 6).

As regards the materials detected before being processed, the vast majority was metallic scrap containing radioactivity of natural origin. Additionally, there were some human-made radioactive sources as well as some other radioactive materials (such as indicators with luminous paint, smoke detectors, lightning rods, consumer goods) containing isotopes of thorium, radium and depleted uranium and parts contaminated with radionuclides of artificial origin. In general, the detected materials were not especially significant from the radiological point of view, although there were certain exceptions to this. The next chapter provides detailed information on this subject, while the corresponding data related to the incidents caused by the processing of radioactive sources is included in Session 4 of this Conference.

At the root of the success of this initiative is the attitude of the industry involved and of its personnel at all levels. They were able to accept and learn from the important training and information efforts that were made on their behalf.

2.6. Authorizations for the transfer of responsibility for the use of radioactive materials

The specific national legal framework establishes the administrative concept of 'Authorization for transfer', as the mechanism by which any possessor of a radioactive material not subject to the control system in force may request the competent authorities to transfer the responsibility over such materials to ENRESA, as the company authorized to manage them.

This mechanism has been well used and is an important asset in the national control system and a complement to the specific campaigns described in this document.

This administrative arrangement has been in force for more than 20 years. Up to December 2007, more than 200 such authorizations have been issued, with the removal of almost 250 radioactive sources.

Approximately half of the applicants did not possess the corresponding authorization for use, the other half were authorized facilities at which certain radioactive sources had not been declared, almost always for historical reasons.

2.7. Potential future actions

Based on the different actions described above, as well as on the accumulated experience on the control of radioactive sources and materials in Spain, the need for additional urgent and/or large actions to avoid serious consequences to people and/or the environment due to 'uncontrolled' radioactive sources is not foreseen. Nevertheless, a few ideas should be considered for the future:

- The continuation of the existing 'Protocol for the radiological surveillance of metallic materials' and its improvement based on the experience of its use;
- The continuation of the administrative arrangement to transfer responsibility for the use of radioactive materials, taking advantage of the

experience gained during the on-going campaign for the location and recovery of orphan radioactive sources. This method of safe radioactive sources management should be kept open;

— Continuous attention to the actions to be taken in the coming years, within the Spanish health system (both public and private) for the replacement of 'old' teletherapy equipment with new technologies, including consideration of the final destination of the disused radioactive sources;
— Close tracking of the evolution of the regulatory control system applicable to activities involving the use of materials containing radioactivity of natural origin and their implications in the management of the residual materials deriving therefrom.

3. SUMMARY OF THE EXPERIENCE GAINED THROUGH THE APPLICATION OF THE 'PROTOCOL'

3.1. General

The Spanish 'Protocol' was presented in Session 2 of this Conference. As has been pointed out, the text of this protocol establishes the need to maintain oversight of the potential radioactive content of metallic scrap entering facilities, as well as of the corresponding end products and waste materials, where applicable. Likewise, the protocol defines the actions to be taken in the event of detection, either previously or subsequent to the processing of materials with radioactive content.

The detection systems to be implemented by the subscribing companies are defined on the basis of the Protocol and may have differing levels of complexity and sophistication. Automatic systems (gate monitors) are used in the case of industries that process the materials they receive. Where appropriate, these automatic systems are complemented with manual systems and even with more accurate analytical equipment for use in smelting processes, with the dual purpose of increasing radiological safety at the facility and of guaranteeing the quality of the end product obtained.

Figure 7 shows the basic approach to be adopted for application of the Protocol in the most general case, which consists of using automatic detection systems and of the material entering in trucks. In summary, the following actions should be taken in the event of detection at the entry to the facility:

— Confirmation of the alarm;
— Isolation of the load;
— More detailed measurement to locate the radioactive material;

— Segregation, storage and custody of the radioactive material until it is removed by ENRESA;
— Notification of the events to the CSN, with special urgency when the radiation levels are high.

When detection occurs in the end products or by-products of the process applied, the following actions should be taken:

— Interruption of the production process;
— Immediate notification to the CSN;
— Assessment of the situation, with the necessary specialist support;
— Preparation and performance of a plan for cleaning and removal of the radioactive material, with the necessary support and advice from the CSN and ENRESA.

For the efficient application of the Protocol it has been necessary to undertake informative and training programmes for the personnel of the subscribing companies at different levels, from basic aspects helping with the visual identification of suspicious parts (brochures, posters, etc. which have been widely distributed), to courses and sessions of a higher technical level aimed at those directly responsible for the detection equipment and at responsible management.

In any case, the assessment of the radiological significance of a situation and the characterization and handling of the radioactive materials requires intervention by personnel with expert knowledge of radiological protection. For this reason, the subscribing facilities have established agreements with specific organizations authorized to provide such support whenever required.

In addition, both the CSN and ENRESA, as specialist organizations, have responsibilities assigned to them in the Protocol. In this respect, a varied series of actions has been carried out within the framework of a specific technical group, such as the following:

— Development of practical procedures for action in the event of radioactive sources or materials having been processed;
— Research and development projects for the harmonization and optimization of the operation of existing gate monitors (see Section 3.3);
— Information and training programmes and activities.

3.2. Summary of actions and results (incidents not included)

— The total number of detections is summarized in Fig. 5. The general pattern seems to be about 100 detections per year. All detections are duly notified by the installations to the CSN, which makes periodic requirements to ENRESA for further investigations and radiological characterisations as well as for the removal and safe management of the radioactive materials found. In total, ENRESA has received 323 such requirements since 1998; in general, the time between such a requirement and the removal of the material is 1–3 months.
— ENRESA has performed a total of 320 actions, with removal of radioactive materials in 224 cases (the rest being NORM with low radiological significance) (see Fig. 6).
— ENRESA has investigated a total of 2320 pieces of radioactive material of very different kinds and radiological significance, from which, 268 were true radioactive sources, either shielded or unshielded, and 2052 other types of materials, as follows:

• Compacted materials	6
• Metallic pieces with NORM	726
• Metallic tubes with NORM	388
• Metallic pieces with artificial radioactivity	72
• Products with Ra-Th	553
• Smoke detectors	126
• Lightning rods headers	47
• Pieces of uranium	31
• Other debris and sand	62
• Other	41

— Figure 8 presents the distribution by radionuclide and by origin of the 268 sources controlled, while Fig. 9 shows the distribution by content of the total 2320 pieces of radioactive material investigated since 1998.
— In Fig. 10, there are some examples of the different kinds of radioactive sources and other radioactive materials detected over the years.
— There have been a total of 30 training courses for people from the different installations which have signed the Protocol (a total of 622 participants). There are seven more courses already scheduled for 2009, including two specifically devoted to applying the results of the work done to harmonizeharmonize and optimize the operation of the gate monitors (see Section 3.3).

3.3. Harmonization and optimization of gate monitor operation

Since the Protocol was signed, some 300 gate monitors have been installed in Spain. No homogeneous criteria exists for their verification and optimum operation. In compliance with what was established in the Protocol, a project was undertaken to improve the existing in-house knowledge as well as to harmonizeharmonize the verification and calibration processes for this type of monitor. This project was financed by the CSN and ENRESA and was performed by the Polytechnic University of Madrid.

Its basic objective was to harmonize the operating parameters of the existing gate monitors, with three specific objectives:

- To establish procedures to ensure that gate monitors operate correctly;
- To establish procedures to harmonize their detection capacity, regardless of the location in which they are installed;
- To recommend reference alarm levels to ensure optimum detection.

The project was conducted in three stages:

(1) Study and analysis of the available information on international standards and experiences with these monitors to improve in-house knowledge.
(2) Design and implementation of a set of initial tests, based on which an additional final test was designed and performed covering 19 gate monitors located in a sample of the different existing facilities and types. Two types of tests were performed during the project: static and dynamic, using a calibrated source of Cs-137.
(3) Analysis of the results obtained and definition of technical procedures for gate monitor verification and calibration, as well as recommended reference values to compare with the verification and calibration results. The documentation produced includes the theoretical basis, recording forms and procedures to calculate the different parameters to adjust the monitor in accordance with the generic standards for radiation measuring equipment.

These technical procedures recommend three basic and simple testing processes to be performed:

(a) Report on the **initial installation** of the equipment, which should contain the basic operating data.
(b) Periodic and simple **verification** of the gate monitors to ensure correct operation, performing a Static test.

(c) Annual **calibration** to evaluate the detection capacity and ensure that this capacity is appropriate, performing a Static and a Dynamic test.

The **verification** includes two types of processes to be carried out by the user of the equipment or by some other qualified person: **(a) Qualitative verification** is recommended every two weeks, or at least once a month, and includes operating parameters and the correct operation of vehicle sensors and acoustic and luminous alarms by using exempted radioactive samples and (**b) Quantitative verification** is recommended monthly, or at least quarterly, and consists of a static test to calculate efficiency at the surface of the panel. The source is placed at a central point in contact with the panel surface (see Fig. 11).

The **Calibration** process consists of two tests that should be performed by a well trained and qualified person using a calibrated radioactive source of Cs-137 of 370 kBq:

(a) **Static test**, performed by positioning the source at the centre of the sensitive detecting zone of the gate monitor, i.e. equidistant between the two detectors and mid-height on the panel (see Fig. 11). Static efficiency is calculated and the margin of variation should be checked to be below 10%;
(b) **Dynamic test**, to check that the detection level is better than the recommended **reference value**. The dynamic test is performed under moving conditions; a person passes through the centre path of the sensitive zone (between panels), with a source placed mid-height and equidistant.

At this time, the process of implementing the technical procedures developed in the project and designing the corresponding training programmes is underway. Subsequently, they will be reviewed and eventually revised and published as a document of the technical group established in the Protocol.

At the beginning of 2009 a new project was launched, as a continuation of the previous one, with three basic objectives:

— To determine the detection capacity of gate monitors for a wider range of gamma and beta energy emitters than the previous project.
— To further adjust and optimize the response of latest generation monitors with detection capability in several energy ranges, to help in the identification of the emitters and in the segregation of natural sources.
— To conduct a state of the art analysis including monitors with the capacity to perform gamma spectrometry as well as neutron detection (both, fixed and portable), including several types and configurations for their installation and use, and using either GeHP and/or NaI(Tl) detectors.

3.4. Key lessons learned over a 10 year period

- The detection and subsequent removal of radioactive sources and/or materials inadvertently incorporated in scrap metal is technically and administratively feasible. At the country level, this process requires the active participation of several national organizations, which should be convinced of the value of the process for their respective interests.
- The key and ultimate goal should necessarily be preventive, that is, to avoid such sources and materials entering into the chain. This prevention can only be successfully achieved through internationally coordinated actions. In this respect, there is a lot of room for action to be taken by the relevant international bodies, including those representing the global scrap metal trade.
- Radiological characterization of a true radioactive source (either shielded or unshielded) is not a very difficult technical task, other than in certain specific cases (very high activity sources and/or specific sources with alpha or weak beta emissions). There are however greater difficulties when it comes to performing detailed characterizations of metallic or other materials containing or being contaminated with NORM, and this point is crucial to properly determine the most appropriate management route after detection.
- The return of sources and other radioactive materials detected to the country of origin has proven to be extremely difficult, for different reasons. This is an area which needs additional efforts at the international level.

The case of detected materials containing or being contaminated with NORM is especially complex for many reasons, starting with the basic recognition that such materials may have a completely different administrative status in different countries (valuable recyclable materials or radioactive waste). This point requires urgent consideration internationally.

- The direct involvement of workers (including their trade unions) and the efforts to provide open information and proper training to all of those involved, or simply having an interest in this issue, has proven to be very useful.
- Based on our experience, it has been positive to keep the requirements and obligations established in the Protocol at a non-prescriptive and voluntary level. However, this might be country specific.
- The real success of the whole procedure may be challenged if detection is not directly followed by an operational action to remove and properly manage the materials detected.
- And finally, of course, there will always be financial implications, which should be properly and clearly addressed in the system.

ACKNOWLEDGEMENT

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ANNEX: List of figures (TO BE FOUND IN THE POWER POINT PRESENTATION)

THE NEED FOR TRAINING IN THE METAL RECYCLING INDUSTRY

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Abstract

This paper describes the experiences of an Argentinian steelmaking company in installing and operating equipment for detecting radioactive material in scrap metal. The lessons learned and the improvements made on the basis of the experience gained are documented.

1. INTRODUCTION

Acindar is a steelmaking company formed by private capital (ArcelorMittal). Its operations started in 1942, with a plant in Rosario (Santa Fe). Today, it is the biggest private producer of non-flat steels in Argentina, with a market share of more than 50%. It has 11 plants at six locations and produces more than 200 product lines for different markets. It employs approximately 3000 people. It has a steel production capacity of 1 400 000 tonnes/a. ArcelorMittal is the leading steel producing worldwide, with a capacity of 110M tonnes, 10% of the world's production. Acindar consumes 32% of the scrap market in Argentina, that is, 1 212 000 ton/a.

2. THE IMPORTANCE OF TRAINING

Training is fundamental because it affects not only the way people think, feel and behave, but also their beliefs, values and goals. The context is detecting radioactive material in scrap metal and in this context the goal must be to prepare all involved persons for the execution of diverse tasks and responsibilities.

3. INTEGRATED SYSTEM FOR DETECTION OF RADIOACTIVITY

Before 2005, the company did not possess systems to control the incoming scrap. The Nuclear Regulatory Authority (NRA) in periodic meetings on the problem of the radioactive sources in scrap (in which information about incidents reported by other countries was discussed), proposed the development of a culture of prevention.

Acindar considered Arcelor's reference document, regarding the management of possible radioactively contaminated materials in metal scrap, as well as the reference document from the Arcelor Committee on Radioactivity (2004).

It was decided that it was necessary to control the entrance of the scrap into the facility and therefore a project was generated to buy and install a portal detector. The decision to incorporate high technology equipment necessitated modifying processes and the relocation of the scrap park, as well as qualifying the personnel to manage the new system.

4. FIRST STEPS

— Advisory visits by the NRA;
— Consultations within the ArcelorMittal group;
— Consultations and advice from potential suppliers;
— Evaluation and definition of the mechanisms and devices to install and their needs;
— Basic Training on Radiological Safety in relation to radioactive sources;
— Specific information on safety in the use of the radiation detectors;
— Obtaining licence (like operator of radioactive sources);
— Appointment of Responsible Person for the company in relation to the NRA;
— Identification of the workers who have a potential for receiving a radiation dose during these activities.

4.1. Detection equipment

— Entrance portal detector;
— Crane detectors at scrapyard;
— Melt shop lab detector;
— Gas and dusts extraction ducts;
— Outgoing portal detector;
— Portable detectors and dosimeters.

4.2. Entrance portal detector

This consists of a large plastic scintillation detector installed at each side of the gate together with a truck movement detector. The unit will alert in case of:

— Radiation above the established limits;
— Truck speed if it is higher than 5 mph;
— Variations in the calibration of natural background level;
— Detained vehicle;
— Radiation below the background level.

The system enters a record of every event in a printout and has a modem communication capability.

5. GENERAL EXPERIENCE

5.1. What went well

— Initial training of the technical personnel;
— Maintenance plan;
— Diagnosis and consultation by phone;
— Definition of the general and specific procedures for control, operation and emergencies;
— Routines of calibration.

5.2. Experiences with operation

The following deviations were detected:

— **An alternative entrance was used by a truck without a portal detector. And, the lack of training of security personnel was apparent**. The personnel were trained, a manual with instructions was provided and they were instructed in situ. Additionally, a barrier with a padlock was installed, and the signals to the drivers were improved to make the system less vulnerable.
— **Failure of monitor to operate due to interruption of the energy supply and lack of procedure in case of non-functioning portal detector**. The dependability of the system was improved by installing a battery to assure the energy provision. The general procedure (SEG-054) was modified and manual detectors were purchased.

— **Alarms activated by refractory material containing NORM.** The material is now separated and checked and NRA is informed. A sample of 20 trucks with refractory material was used to fix a reference value for this type of load.
— **Real alarm without vehicle in the portal.** After several hours of investigation, it was discovered that a contractor was carrying out gamma radiography to a duct located 300 m from the entrance portal.
— **Real alarm in an oxygen truck**. A source was in the level meter of the cistern of the truck. Security was informed.

As consequence of these experiences, the following measures were implemented:

— A technical report was produced on the level of sensitivity (**σ**) in terms of dose rate at the portal in relation to the detection of radiation from scrap; this was validated by the NRA;
— The NRA was consulted to bring up to date general and emergency procedures. The involved personnel were retrained;
— Development of software to identify events (truck identification and driver);
— Software for administration of alarms (warnings);
— Background information gathered as backup for the decision to install a new detection portal;
— Additional training to safety technicians, doctor and melt shop projects engineer;
— Improvements to the awareness to the operators of continuous casting.

6. CRANE DETECTORS AT THE SCRAPYARD

In 2007, Acindar decided to outsource the operation of the scrapyard to a third party. The scrapyard was relocated and the operation was performed by Multiserv. The system installed at the scrapyard consists of a detector in the crane and a transmission of data to the crane booth.

6.1. Experiences

— **The new operations were defined**. Specific and emergency procedures were developed.
— **Lack of training of contractor's new personnel**. The personnel were qualified, a handbook produced and they were trained in situ.

— **Continuous energy needed for unit mounted on a mobile structure.** Battery RF equipment was installed, with daily recharge.

7. MELT SHOP LAB DETECTOR

This consists of two sodium iodide detectors and a multichannel radioactivity analyzer.

7.1. Experiences

— **Lack of knowledge and experience.** Basic training provided by supplier; for extra *specific* training – consultation with supplier.
— **Record data storage necessity.** Appropriate connection of the equipment.
— **Definition of the necessary test pattern.** Studies and prototypes to define the most appropriate pattern.

8. GAS AND DUSTS EXTRACTION DUCTS

— There is no control over gases and dusts generated;
— A system on the air ducts for separate dust analysis with online data is being evaluated and budgeted;
— Benchmark with other ArcelorMittal plants;
— Project engineer personnel training.

9. NEXT STEPS

— To create a work group — at a national level — led by the NRA to establish common norms and procedures of radiological safety with the objective of sustaining an appropriate level of radiation protection;
— To achieve knowledge and experience exchange on a permanent basis to help unify criteria;
— To establish awareness needs of the principal players involved in the scrap handling process;
— To work together with scrap collectors, recyclers, steel manufacturers, customs, government departments and non-governmental organizations.

MANAGEMENT OF INCIDENTS WITH CONTAMINATED SCRAP METAL

(Session 4)

Chairpersons

E. AMARAL
IAEA

Rapporteur

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IAEA

SUMMARY OF SESSION 4

MANAGEMENT OF INCIDENTS WITH CONTAMINATED SCRAP METAL

In this session a number of incidents and experiences with scrap metal containing radioactive material were described.

The presentations illustrated the wide range in the scale of the monitoring being used in different countries. In some countries monitoring at scrap metal yards and metal processing factories is either very simple or non-existent. In others, the monitoring systems are very extensive and sophisticated with detection systems at all entrances and exits, in the metal processing plant, at the plant dust collection facility and in the gas exhaust systems. Since the scrap metal industry is truly global with loads moving between most countries in the world, these differences in the level and extent of monitoring help to explain the continuing problems with radioactive material in scrap metal.

The accident in Seville, Spain in 2001 involving a ^{137}Cs source melted in a steel processing plant shows the magnitude of the costs that can result from such an incident. To enable the cleanup operations to be completed after the incident, the plant was closed for one month. The cost of the cleanup and waste management exceeded 3 million euros; this does not include the cost of the loss of production.

Recent incidents involving the discovery in France and Germany of metal components imported from abroad containing low levels of ^{60}Co illustrate the global nature of the problem. Although the levels are not such as to cause harm due to radiation exposures, the existence of radioactive material in the metal components is sufficient to disrupt the business of companies and to lead to a loss of confidence in the products. The problem clearly lies with the loss of control over radiation sources and the inadequate radiation detection systems at the premises of the scrap metal supplier and the metal melting facility. Finally, the import of the contaminated metal components into France and Germany had gone undetected at international airports.

An incident in Mexico involved ^{137}Cs being found in steel dust. Again, the levels were not high enough to cause radiation harm but problems were caused because the nuclear regulator had no jurisdiction over the facility where the material was discovered. Further, the country has no radioactive waste disposal facility and so the final disposal of the contaminated steel dust also presents a problem.

In the panel discussion after the presentations the following points were raised:

It was noted that in several of the incidents described in the session the international Convention on Early Notification in the Event of a Radiation Accident had not been invoked and that no notification had been given of the incidents.

The incidents described in the session provide strong evidence of the global nature of the problem but is the situation getting better or worse? The evidence seems to be inconclusive. The Code of Conduct has undoubtedly increased awareness in countries but sources now entering the metal scrap chain were probably lost from control before the Code of Conduct came into being. Also, metal products are being produced and exported from more countries nowadays some of which have inadequate control and detection systems.

For large metal producing companies, the risks associated with radioactive contamination in their products are: health risks, financial risks and reputation risks.

There are examples in Spain, Germany and Sweden of steel from the nuclear industry being accepted by metal producers. In all cases this is because the metal industries concerned know and trust the supplier, are aware that the scrap quality is good and are confident in the quality assurance methods being employed.

SWEDISH EXPERIENCE AND LESSONS LEARNED FROM CONTAMINATED SCRAP METAL

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Abstract

Sweden has so far only had a few incidents involving contaminated scrap metal, none of which has led to any hazardous consequences for human health or the environment. This paper reviews the development of the monitoring of scrap metal at the Swedish border, at scrapyards and at steel mills. Five incidents in which radioactive sources have been melted together with scrap metal at Swedish steel mills have been reported to the Swedish authorities. These incidents are described here, as is a recent incident in which a Swedish company, in October 2008, imported steel products contaminated with cobalt-60; this is the first reported incident involving contaminated products in Sweden. The Swedish scrap metal suppliers find a number of contaminated items in their incoming scrap metal shipments every year; a survey of reported incidents is given here. Finally, lessons learned are discussed from a regulatory point of view.

1. MONITORING OF SCRAP METAL AT THE SWEDISH BORDER

Because of several cases of suspected uranium smuggling early in the 1990s, Swedish Customs reinforced the control of shipments of scrap metal arriving from, in particular, the Russian Federation and the Baltic countries by investing in hand-held gamma detectors. Until then, there had been no radiological control of the import of scrap metal to Sweden. During the 1980s, the import of scrap metal was quite substantial; from time to time the total need of the Swedish steel industry for scrap metal was supplied by imported material from the Russian Federation.

In 1992, a shipment of copper scrap arrived in Stockholm harbour by boat from Estonia. Thanks to the new instruments, Customs detected elevated levels of radiation from the container. Further analyses showed that the copper was contaminated with cobalt-60 (specific activity 10 kBq/kg). The container was shipped back to the Estonian supplier. It was not possible to discover the origin of the copper.

This was the first reported Swedish incident with contaminated scrap metal and, as a result, Customs immediately intensified the surveillance at the border. Collaboration between several Swedish authorities resulted in the issuance in

1994 of Guidelines by the Swedish Customs on the surveillance of contaminated scrap metal at the border [1], which, among other things, describes what measures need to be taken if radioactive material is found. Following the issue of the Guidelines, Customs focused their surveillance on the traffic from the Russian Federation, the Baltic countries and Poland. All shipments were to be monitored if they contained scrap metal.

In the early 2000s, Swedish Customs applied for, and was granted, money from the former Swedish Emergency Management Agency for ten portal monitors, to be located at key border points. However, Sweden's interpretation of the EC treaty granting free movement of goods between Member States of the European Union was — and is — that such monitoring would be in violation of the treaty. The portal monitors were, therefore, never bought. Customs did, however, invest in three monitoring cars, for emergency preparedness purposes. No regular monitoring of shipments entering Sweden is performed by Customs today, irrespective of the shipment's origin, i.e. either from within the EU or from a third country.

1.1. Reshipments of undeclared radioactive materials/wastes

As a general policy, radioactive waste of non-Swedish origin must not be disposed of in Sweden. Certain treatments and the handling of foreign radioactive material and radioactive waste do take place by licensed companies in Sweden — but the waste residues must be sent back to the country of origin.

In cases where radioactive material is shipped undeclared to a Swedish consignee who does not have a licence to process radioactive material/waste, the material likewise must be sent back to the consignor in the country of origin.

The procedures for reshipment of contaminated materials, which can be classified as radioactive waste, follow applicable requirements in 'Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel' [2]. For undeclared materials/waste, Article 4 of the Directive [2] specifically acknowledges the right of a Member State to safely return to its country of origin:

(a) Shipments of radioactive waste and spent fuel which fall under the scope of the Directive but which were not duly authorized in accordance with the Directive;
(b) Radioactively contaminated waste or material containing a radioactive source where this material has not been declared as radioactive waste by the country of origin.

For materials not covered by the Directive [2], a similar approach as that set out in the Directive applies, i.e. the Swedish Radiation Safety Authority (SSM) will contact the competent authority in the country of origin to have its approval for the return of the shipment. This is a straightforward procedure, even though it may take some time before all parties are in agreement on the procedures that should take place.

Naturally, for return shipments, the material must be properly declared and requirements for the safe transport of dangerous goods must be met.

2. IMPORT OF CONTAMINATED STEEL FLANGES, OCTOBER 2008

On October 7th 2008, a Swedish company that sells products for the oil and offshore industry contacted the Swedish Radiation Safety Authority (SSM) asking for advice on how to measure stainless steel components (flanges), believed to be contaminated with cobalt-60. The products had been imported from India earlier that year and the company had been informed by their shipping agent that products from the same Indian firm had been stopped from being imported into the EC by Customs in Rotterdam. The company wanted to make sure that they did not have any contaminated products in stock. SSM immediately contacted the Swedish Customs who sent a qualified monitoring team to the company the same day. The team established that less than a dozen of the flanges were contaminated with cobalt-60. The dose rate was about 4–5 microsievert per hour near the surface. Later on, the analysis of a sample confirmed that the components were indeed contaminated with cobalt-60 (specific activity < 40 kBq/kg).

The company had to explain to the authorities how their products were distributed in Sweden. At the same time Swedish Customs tracked down three additional Swedish companies that had received imported items from the Indian firm. Monitoring teams visited all identified potentially affected companies to conduct measurements. A week after the authorities were first informed, a monitoring team found a few contaminated products at one of the other companies. The dose rate was the same as earlier, 4–5 microsievert per hour at the surface. No other findings were reported from the investigations. When cobalt-60 contaminated elevator buttons of the same Indian origin were found in France, SSM made sure that all elevator buttons in Sweden were measured. No contamination was detected.

SSM has decided that all contaminated products found in Sweden should be sent back to the supplier abroad. To avoid further import of contaminated steel products from this particular Indian firm, Swedish Customs has listed five foreign companies that might ship products from the same firm. If any imported material arrives from these companies Customs will conduct measurements.

This is the only reported incident involving imported contaminated steel products in Sweden.

3. MONITORING OF SCRAP METAL AT SWEDISH SCRAPYARDS AND STEEL MILLS

Sweden has so far only had a few incidents involving contaminated scrap metal, none of which has led to any hazardous consequences for human health or the environment. The Swedish steel and recycling industry does not allow any radioactive material to enter the steel process flow; there is a ‘zero tolerance’ policy. The zero tolerance not only applies to the final products distributed on the market, but also to the by-products such as slag, dust, sludge, etc. Below is a description of the measures taken by the industry in order to guarantee that no radioactive material enters the steel process flow.

3.1. Joint cooperation

The steel mills and the scrap metal suppliers cooperate with the purpose of jointly securing that all radioactive material is detected before it enters any processing equipment in the material flow — such as shearers, shredders or melting furnaces. The cooperation is administrated by JBFAB, a company owned by the major Swedish steel companies and acting as their purchasing agent for scrap on the Swedish market and in the Baltic region.

The steel and recycling industry has, as a result of a joint effort over the years, published The Swedish Scrap Book [3] which is regularly updated. The main purpose of the book is to achieve a higher efficiency in the recycling of scrap metal by regulating specifications on purchasing and production of different qualities. The Scrap Book establishes that it is the responsibility of the scrap metal suppliers to deliver scrap metal free from radioactive material to the steel mills.

In JBFAB’s scrap specifications, it is clearly stated that shipments of scrap metal to the steel industry must be free of radioactive material, be it imported or of Swedish origin. For imported scrap metal, the European Steel Scrap Specification applies: ‘shipments may not contain radioactive material in sealed containers even if no significant exterior radioactivity is detectable due to shielding or due to the position of the sealed source in the scrap delivery’. The companies that import scrap metal are obliged to control the material before it leaves the country of origin.

In 1996, the former Swedish Radiation Protection Authority (SSI) issued Guidelines on general rules on the monitoring of scrap metal [4]. In the Guide, SSI recommended that all scrapyards and steel mills with monitoring systems should have a documented action plan on how to monitor and handle contaminated material. The industry followed this advice; all radioactive sources found are separated from the flow and taken care of according to documented routines.

3.2. Monitoring

The industry has increased the control of scrap metal the past two decades. Steel mills have portal monitors, as do many of the largest scrap metal yards. In total, the industry has approximately 40 portal monitors spread over the country. In addition, some yards have detecting equipment in crane grips and transportation units. There are also a number of hand-held instruments. Employees receive information and education on a regular basis with the goal that they should be able to handle the monitoring equipment but also to visually detect sources of different kinds. The final monitoring step of the steel process flow is when steel ingots, slag and dust from the melting furnaces are analyzed for radionuclides.

3.3. Insurance policy

In the event of failure to detect a radioactive source of some kind, the Swedish steel and recycling industry has a joint insurance. The insurance is valid for incidents with contaminated scrap metal not detected by the companies' monitoring systems, and where the material thus enters any processing equipment (e.g. shredders or melting furnaces). The insurance covers direct clean up costs, loss of production, indirect clean up and damage costs claimed by third parties, personal injury for employees and claims from third parties. The insurance includes a self-insured retention amount.

3.4. Management of detected radioactive material

According to the Scrap Book [3], should a scrapyard or steel mill find radioactive material in a shipment of scrap metal, the material can be sent back to where it came from, and the owner has to pay a penalty fee. The owner can also choose to let the scrapyard/steel mill take care of the contaminated material. The owner then has to pay the costs for the management of the material in addition to the penalty fee. As long as ownership is clear, there is no problem as to who is financially responsible for the contaminated material.

However, now and then, radioactive material is found among scrap metal for which it is impossible to establish the owner. This is particularly common for the scrap metal suppliers. More often than not, these shipments come from municipal recycling sites, where anyone can get rid of anything with virtually no control. In the end, the scrapyards have no one to charge for the costs for the management of the scrap and are left with the financial responsibility themselves.

Another problem for the industry is the uncertainty as to whether the radioactive material will be accepted by Studsvik Nuclear AB, which is the only Swedish licensed company that manages radioactive waste. At the moment radioactive material is stored at the scrap suppliers, only exceptionally has the material been transported to Studsvik. The industry has recently engaged in discussions with the authorities and Studsvik Nuclear AB, to find a solution. Studsvik is currently making an inventory of the different kinds of radioactive material stored by the industry, to see if there is waste they cannot accept. With respect to financial aspects, a possible short-term solution for the recycling industry is to apply for money from SSM to cover the costs for the management and final disposal of the material. SSM receives special funding corresponding to EUR 100 000 per year from the Government, to cover the costs for the management and final disposal of non-nuclear waste from past practices and orphan sources.

3.4.1. Incidents with contaminated scrap metal at Swedish steel mills

It is not mandatory for Swedish steel mills to report incidents with contaminated scrap metal to the authorities. Five incidents have been reported where radioactive material was melted in melting furnaces, none of which has led to any hazardous consequences for human health or the environment.

The first time the Swedish authorities were made aware of an incident in which a radiation source was melted in a Swedish steel mill was in 1996. The contamination at this particular steel mill was detected during routine monitoring of the steel ingots. The contaminated material was put aside and the authorities contacted. The authorities analyzed the material further and stated that the radioactive source that had been melted together with the scrap was cobalt-60 (100 MBq). It was not possible to establish where the source came from or if it was of domestic or foreign origin. 150 tonnes of material were contaminated with cobalt-60, of specific activity 700 Bq/kg. The authorities concluded that the material was of no hazardous concern from a radiation protection point of view and recommended the steel mill to keep the material on the site for a few years to allow it to decay.

In 1998, an iridium-192 source (9 GBq), probably shielded, passed the portal monitor of a steel mill without the alarm sounding. In the end, the iridium-

192 source was melted together with 100 tonnes of steel, resulting in a steel specific activity of 90 kBq/kg. When discovered, the contaminated material was put aside to allow for decay. The authorities inspected the steel mill and monitored both the interior of the factory and the surroundings. There were no demonstrable effects from the contamination. The steel mill investigated the origin of the iridium-192 source. The conclusion was that it came in a shipment of imported scrap metal, most likely from the Russian Federation.

On three different occasions, americium-241 sources have been melted in steel mills, one in 2001 and two in 2005. All three meltings were discovered during routine monitoring after the melting process. In 2001, the company's routine monitoring did not include monitoring of the slag, where the contamination was found, but this time some of the slag had mistakenly been incorporated into the steel ingots that were analyzed, thus allowing for detection. Ten tonnes of slag were contaminated, five tonnes had a specific activity of 11 kBq/kg and five tonnes of 5 kBq/kg. The authorities therefore concluded that it was an 80 MBq americium-241 source that had been melted with the scrap metal. The origin of the source was not established.

In 2005, the monitoring routines included monitoring of not only the melting batches but also the slag and the dust. One of the melted americium sources resulted in 10 tonnes of slag with a specific activity of 1–1.5 kBq/kg, which suggests an americium-241 source of 10–20 MBq. The activity of the other americium source melted that year was considerably higher activity, 1.5 GBq, resulting in five tonnes of contaminated slag (300 kBq/kg) and five tonnes of contaminated dust (5 kBq/kg). Again, the origin of the sources has not been established. The authorities have inspected and monitored all three steel mills, and found no elevated levels of americium-241. At the steel mill where the 1.5 GBq americium-241 source was melted, the workers working closest to the melting furnace and the contaminated slag were sent for an internal examination. No detectable activity was found on any of the workers.

3.4.2. Incidents with contaminated scrap metal at Swedish scrapyards

Just as for the steel mills, it is not mandatory for Swedish scrap metal suppliers to report incidents with contaminated scrap metal to the authorities. Table 1 shows the number of incidents reported to the authorities between 1997–2007 in which radioactive material has been found in incoming scrap metal shipments at Swedish scrapyards.

Some examples are also given of the kinds of radioactive material that has been found. The reports the authorities have received over the years therefore do not reflect the reality. The trend in the past eight years or so is that fewer and fewer incidents are reported to the authorities. Since the scrap metal suppliers

TABLE 1. NUMBER OF INCIDENTS REPORTED TO THE AUTHORITIES 1997–2007 IN WHICH RADIOACTIVE MATERIAL HAS BEEN FOUND IN INCOMING SCRAP METAL SHIPMENTS AT SWEDISH SCRAPYARDS

Year	N° incidents reported	Examples of reported objects	Nuclide
1997	1	Pipes and metal parts from paper mill (scale)	NORM
1988	1	Scintillation counters	Ra-226
1999	3	Thickness gage Laboratory balances	Am-241/Be Ra-226
2000	5	Rotors from helicopter	Cs-137, Th-232
2001	8	Metal parts from a vehicle Measuring instrument	Cs-137 Co-60
2002	12	Luminescent switches Motor parts from airplane	Ra-226 Th-232
2003	9	Radium emanator Airplane instrument panels	Ra-226 Ra-226
2004	2	Luminescent paint	Ra-226
2006	1	Smoke detectors	Am-241
2007	2	Dewpoint measuring instrument Jet engine from airplane	Am-241 Th-232

have invested in more detectors during the same period, the number of incidents probably has not decreased as indicated by the reporting.

The most serious incident at a scrapyard, from a radiation protection point of view, was when a thickness gage (4.4 GBq Am-241/Be) was found in a container that passed a portal monitor at a car scrapyard. The gauge was intact and shielded and had been used for measuring asphalt at road constructions. The gauge probably had been used, and lost, by a Swedish company but it was not possible to establish the ownership.

4. LESSONS LEARNED FROM A REGULATORY POINT OF VIEW

The Swedish Radiation Safety Authority (SSM) believes that some sort of surveillance of the Swedish border is needed, not only when it comes to controlling shipments from countries outside the European Union, but also from within the European Union. Such legal objections, real or perceived, should be removed so that the necessary monitoring of goods can be performed, in a non-discriminatory manner, to ensure public health.

In SSM's view, the exchange of information between countries needs to be improved when incidents with contaminated scrap metal occur. Even though an incident might not be particularly troublesome from a radiation protection point of view it can cause huge financial consequences for the parties involved and for society. Considering the extensive international trade in both scrap metal and steel products, the immediate reporting of contaminated components in, for instance, Sweden could prevent financial and/or radiological consequences in other countries.

Today, SSM places no requirements on the steel and recycling industry to report incidents with radioactive material. However, both the authority and the industry consider the reporting to be necessary, for different reasons. Since both parties agree on this matter, it is only a question of how to develop an efficient reporting system for the future.

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RADIOACTIVE CONTAMINATION IN STEEL PRODUCTS — INDIAN EXPERIENCE

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Abstract

Radioactive sources in both sealed and unsealed forms are used in a wide variety of applications in medicine, industry and research for societal benefits. These applications of radioactive sources are controlled in each country by the respective national regulatory bodies. In spite of regulatory control there are incidents of theft, loss or abandoned radioactive sources worldwide. These lost or stolen sources get into metal scrap used in steel recycling industry. Recently, there have been cases of radioactive contamination in steel products exported by many countries. A few such cases of contamination of material exported from India to foreign countries have been reported to Atomic Energy Regulatory Board (AERB) in India. On investigation it was found that the steel products were made out of steel produced in foundries where radioactively contaminated imported metal scrap has been used. Though the radiological impact of such incident is too low to cause any significant hazard, such incidents are undesirable and need to be prevented. A number of measures were taken by AERB to prevent recurrence of such incidents. These include holding meetings with the concerned associations of exporters and the organization of seminars to improve radiation safety awareness among the manufacturers and exporters. The concept of defence in depth is used for detection of radioactivity in metal scrap by the installation of portal monitors at borders, radiation monitoring at metal scrap dealers, foundries, steel mills, manufacturing units of steel products and finally the radiation monitoring of the final product prior to supply in domestic market or export. In this paper, Indian experience in handling the incidents of contaminated steel products and the general and specific preventive measures adopted in India to control such incidents are described. A suggested action plan at the international level is discussed.

1. INTRODUCTION

Radioactive sources are used in a wide variety of applications in medicine, industry and research for societal benefits. These applications involve use of both sealed and unsealed sources. Radioactivity in such sources varies from a few kBq (μCi) to hundreds of TBq (thousands of curies). The national regulatory bodies in each country control the use of such radioactive sources. It has been observed that in spite of regulatory control there are incidents of theft, loss or abandoned radioactive sources worldwide. These lost or stolen sources sometimes get into the metal scrap used in steel recycling industry and ultimately end up as a consumer product with radioactive contamination. A few such incidents related to the export of contaminated steel products such as steel handle doors, manhole covers, steel tension bars, copper coated steel grounding rods, steel wires, nails and metal straps used for packaging, metal fittings used in hand bags etc. have been reported to the Atomic Energy Regulatory Board (AERB) in recent years. This paper covers the Indian experience of handling such events and regulatory measures initiated by AERB to control them in future.

2. INCIDENTS OF RADIOACTIVE CONTAMINATION IN STEEL PRODUCTS

Most of the early incidents of radioactive contamination in steel products in India were detected in the exported consignments by the importing countries. The cases of such contaminations were intimated to AERB by the Customs authorities, security agencies, national regulatory bodies and the affected companies. On some occasions, the officials of AERB have detected contamination during routine inspection of foundries and warehouses. Most of the contamination identified in steel products was due to cobalt-60, except for one or two cases which were due to iridium-192. Some of the incidents of the contamination in steel products in India are listed in Table 1.

One such typical incident of contamination, as given in Sr. No. 3 of Table 1, involved pull door handles exported by an Indian company to a company based in an outside country. The foreign company stamped its brand name on the product imported from India and was to re-export the same product to many other countries. The radioactive contamination was detected at the port when the consignment was loaded for re-export. AERB was informed of this event by the regulatory authority in that country. Officials of AERB investigated the incident in detail. On tracing back the metal recycling chain from the manufacturer to steel mill to steel foundry, it was noted that the foundry used imported metal scrap for melting in the furnace and a residual slug contained low level radioactive contamination. Probably, the imported metal scrap was contaminated with some disused radioactive sources. However, no further contaminated materials were found in the foundry during the inspection by AERB. The consignment containing contaminated items was returned to India. Some residual contaminated steel pieces were recovered from the premises of the manufacturer of steel products and the exporting company. All the contaminated products were disposed of at an authorized radioactive waste management agency in the country.

TABLE 1. LIST OF INCIDENTS OF RADIOACTIVE CONTAMINATION IN STEEL PRODUCTS IN INDIA

Sr. No.	Date of Incident and initiating event	Description of incident	Origin of contamination	Remarks
1.	Aug. 25, 1991 Information received from NRC, USA.	Steel rods exported to USA. Contaminated with Co-60. Contact dose rate on contaminated material 40 µSv/hr .	Ultimately traced to a scrap dealer. The source was decayed Co-60 from a telecobalt unit. Source pellets found on road. The telecobalt source head was imported as scrap. BARC published a report on it in 1993.	All the contaminated items and active source pellets were recovered and safely disposed of at BARC.
2.	August 20, 2001 Information from Public Health and Environment, Belgium.	Stainless steel flanges exported to Belgium. Contaminated with Co-60 with contact dose rate on contaminated material 10 µSv/hr.	On investigation it was found that imported metal scrap caused the contamination.	Contaminated material was identified and disposed off at BARC.
3.	October 19, 2004 Information from US Customs and Border Protection by email.	Door pull handles exported to Australia. Contaminated with Co-60 with contact dose rate of the contaminated items 70 µSv/hr.	On investigation it was found that the door pull handles were made the raw materials originated from a foundry using imported metal scrap as input materials to the furnace.	All the contaminated items were recalled from Australia and safely disposed off at BARC.
5.	August 18, 2006 Information from US Customs and Border Protection by email	Stainless steel leaf colander found contaminated with Ir-192 source with contact dose rate of the contaminated waste 0.28 µSv/hr	Use of the imported scrap for melting caused the contamination.	Contaminated waste had been segregated and dumped underground at the factory premises.
6.	Nov.16, 2006 Information from US Customs and Border Protection by email.	Manhole covers made out of cast iron found contaminated with Co-60 with contact dose rate on contaminated material 10 µSv/hr.	Use of the imported scrap for melting caused the contamination.	Contaminated material returned from USA and had been segregated; is in the process for safe disposal.
7.	Dec. 2, 2006 Information received through IAEA from UK Environment Agency, UK	Loop of handle straps on hand bags exported from India found contamination with Co-60 with low radiation level	Raw material used to make handles originated ultimately from a foundry using imported scrap for melting.	The materials have come back to India and are being kept securely pending safe disposal.

TABLE 1. LIST OF INCIDENTS OF RADIOACTIVE CONTAMINATION IN STEEL PRODUCTS IN INDIA (cont.)

Sr. No.	Date of Incident and initiating event	Description of incident	Origin of contamination	Remarks
8.	Dec. 28, 2006 During routine inspection by AERB in a steel factory.	Nails used to fix wooden crates found contaminated with unknown radionuclide with contact dose rate 20 μSv/h.	Unable to trace the source of contamination. The company could not remember the exact supplier of the material since such materials are procured locally very often.	The material has been segregated and kept pending for safe disposal.
9.	Dec 29, 2006 During routine inspection by AERB in a steel factory.	Steel coils (2) about 15 kg and 5 kg each found contaminated with unknown radionuclide with contact dose rate up to 1 mSv/h.	Since the material is very old stock (about 10 years old) and found on an abandoned machine, the company could not recollect about the procurement of the raw material	The material has been segregated and kept securely pending for safe disposal.
10.	Mar 26, 2007 Information received from Regulatory Body in Belgium.	Bright steel bars exported to Belgium found contaminated with Co-60 with contact dose rate up to 4 μSv/h.	Use of imported metal scrap for melting in the furnace caused the contamination	The contaminated materials had been segregated and safely disposed of in Belgium.
11.	Letter received from the exporter in India on August 21, 2008.	Stainless steel bright bars exported to the Russian Federation. Also, one container detained at Hamburg en route to St. Petersburg port due to contamination with Co-60. Dose rates on the surface of containers in the Russian Federation and Germany are 0.135 mSv/h and 3.3 mSv/h respectively.	The raw materials were procured from a local foundry cum hot roll mill.	The company is importing back the contaminated items. Also, advised to take necessary precaution to eliminate such contamination. Source of contamination was investigated and found that the company mentioned at Sr. No. 12, supplied the material.
12.	During routine inspection by AERB in the factory September 15, 2008.	Contaminated slags, billets, rods found at the factory. This is the same company, which supplied material to the above mentioned exporting company. Dose rate on the surface of billet up to 250 μSv/h.	Bulk of the input materials for melting in the furnace is imported scrap. This imported scrap caused the contamination.	The company was asked to segregate all the contaminated materials and keep securely pending safe disposal. Advised to do radiation monitoring on all the incoming, outgoing materials.

In another typical incident, as given in Sr. No. 9 of Table 1, the officials of AERB detected contamination in a rolling mill during an inspection that was carried out at the request of the mill. During the radiological survey, two steel coils (about 15 kg and 5 kg respectively) still wound around two old unused winding machines were found to be contaminated. The two machines had apparently not been used for more than ten years. As such, the company could not identify the source of the raw material. The company uses both domestic as well as imported metal scrap. The contaminated material was segregated and kept secure pending its safe disposal.

Fortunately, such incidents have been isolated and the radioactivity levels in the contaminated steel products were low such that there was no significant radiological hazard. The measured radiation levels at the surface of the contaminated products varied, 0.06–250 μSv/h. However, there is always the possibility that higher levels of contamination could be found in the metal scrap that could create a radiological problem in the public domain.

3. RADIOLOGICAL IMPACT OF CONTAMINATION IN STEEL PRODUCTS

Though the radiological contamination in most of such incidents in the past was low, it can no longer be ignored. The awareness that such contamination can be detected in steel products is recent and very few countries have deployed systems for large scale monitoring in the foundries and manufacturing units. As such, many countries may have contaminated steel products in circulation. Even in those countries where systems for monitoring of radioactively contaminated steel products are installed at all entry points, it is very likely that materials imported earlier may have been contaminated and continue to be in use within the country.

An attempt has been made to estimate conservatively the dose that might be received by workers while handling contaminated steel during the process of manufacturing in a typical Indian steel foundry. The dose estimated in this paper is based upon the actual measurement of the radiation dose rate for a steel bundle consisting of 30 contaminated stainless steel bars, 6 m in length, 20 mm diameter and total mass of 465 kg, lying in the factory referred to at Sr. No.11 of Table 1. A study was carried out about the nature of work assigned to the workers during the whole manufacturing process in the foundry which supplied the contaminated materials to the above mentioned factory.

Measured radiation dose rate:

At the centre of the surface of the bundle — 484. 66 μSv/h
At a distance of 30 cm — 288.47 μSv/h
At a distance of 60 cm — 187.05 μSv /h
At a distance of 1.5 m — 74.16 μSv /h
At a distance of 2.5 m — 35.20 μSv /h
At a distance of 3 m — 24.23 μSv /h
Beyond 3 m distance, the inverse square law can be applied.

The whole manufacturing process comprises different stages — unloading of scrap, melting, refining through Argon Oxygen de-Carbonization (AOD), continuous casting, cooling, painting, length measurement, end cutting, surface grinding, storage, loading on to the truck for shipment. The dose estimated at different stages of the manufacturing process reveals that in all the processes, except during painting, the estimated dose to the workers does not exceed 1 mSv, which is the annual limit of dose for the general public. The estimated dose, which is highly conservative, received by the worker during the painting process is about 2.4 mSv. Since such incidents of contamination are occasional and the necessary preventive measures are already taken, such exposure can be considered as happening once in the lifetime of the worker. Also, the work assigned to the workers is such that they are very unlikely to get multiple exposures. The collective dose from the above estimation is about 0.0142 person-Sievert and the maximum dose to an individual is about 2.4 mSv.

4. ECONOMIC IMPACT OF CONTAMINATION IN STEEL PRODUCTS

It is well recognized that radioactive contamination of steel products is undesirable and appropriate measures should be taken in each country to prevent such events. In spite of all the preventive measures in place, the probability of such events cannot be fully ruled out. It is noted that, at present, there are no harmonized tolerance limits for accepting such contaminated material. Different countries have different standards for accepting contaminated steel products. As such, exploration of the possibility of the recycling of the low level contaminated material by diluting to a tolerance level cannot be considered. The safe disposal of the large volumes of the radioactively contaminated steel products is a significant challenge being faced in India. There are more than 300 tonnes of contaminated materials being stored in India pending safe disposal. It is desirable that a harmonized standard of acceptance of contamination in steel products be developed for the benefit of each country.

An estimation of the economic loss due to contamination has been carried out. The calculation is based on the inputs received from an Indian exporter. It is assumed that material (grade 304 stainless steel) is exported to a European destination and returned to the country of origin due to the detection of contamination at the port of destination. The prices used in the calculation are based on the price index prevailing in the steel market in August 2008.

The total cost of production of the material per kg is about US$[1] 3.6 and the selling price is about US$ 3.7. If the material is found to be contaminated and returned to the exporter, the total loss (including freight charges) is about US$ 5.8. There are cases where the exporter has to retain[2] the empty container which has contained contaminated material. The total loss if one full load container is found to be contaminated comes about US$ 126 958; and if the exporter has to retain the container also, the total loss becomes about US$ 131 125.

There is a very high transport charge for the return of the contaminated material to the country of origin. Moreover, suitable carriers are not easily available for the transport of the contaminated material. All these factors may delay the shipment and sometimes deter the exporter from bringing back the contaminated material and so avoid bankruptcy of his company.

5. PREVENTIVE MEASURES ADOPTED IN INDIA TO CONTROL RADIOACTIVE CONTAMINATION

The preventive measures adopted by AERB in India to control the radioactive contamination of steel products are summarized below.

- A consultative meeting was held with the Engineering Export Promotion Council (EEPC), which is the government supported conglomeration of the manufacturers and exporters of engineering products, to create awareness and find ways of avoiding contamination of steel products;
- Several informative articles were published in the news bulletin of EEPC on prevention of radioactive contamination of steel products;
- Three awareness programmes on radiation safety were conducted for the manufacturers, exporters and concerned government officials;

[1] Assuming the current rate of foreign exchange US$ 1 = INR 48.

[2] Some carriers have a policy of not taking back the containers that have contained contaminated material.

— The manufacturer/exporters were advised to procure sensitive radiation monitoring instruments to monitor the incoming raw material and outgoing finished products;
— Officials of AERB conducted more than 50 random inspections of the foundries and warehouses involved with the manufacturing of steel products from scrap steel metal;
— The concerned ministry of the Government of India has been requested to install portal monitors at the entry and exit points of all the international ports in the country. An indigenously developed portal monitor including neutron detector has been installed at Jawaharlal Nehru Port, Nava Sheva; the largest port in the country;
— A notification has been issued through the Indian Gazette that every importer of metal scrap should obtain a certificate issued by the regulatory body or an agency accredited by the regulatory body in the country of export certifying that the metal scrap is free from radioactivity.

India already has in place a strong and effective regulatory control over the use of radioactive sources. Any incident of theft, loss or abandonment of radioactive sources is thoroughly investigated and corrective measures are taken to prevent the recurrence of such incidents. Also, such incidents are reported immediately to the IAEA through the ITDB. The incidence of detection of any radioactive contamination in the country is at once brought to the notice of the AERB. The concerned manufacturers/exporters are advised to ensure the safety and security of such contaminated items pending their final safe disposal at an authorized radioactive waste management agency.

6. SUGGESTED ACTION PLAN AT THE INTERNATIONAL LEVEL

The contamination of steel is not confined to a single domestic market or a country. It has become an international issue since the globalization of trade practices. As such, this problem has to be tackled at the international level. The following is the suggested action plan to be taken up at the international level.

— Mandatory radiation monitoring of the incoming raw material and outgoing finished products in the steel factories using scrap metal as input material should be introduced through suitable national legislation;
— A harmonized standard for acceptance of contamination in steel products should be developed;
— Countries exporting scrap metal should also monitor the consignment before despatch;

- Concerned national regulatory authorities should strengthen the mechanism for certifying radioactivity free steel materials meant for export and import;
- Concerned national regulatory authorities should facilitate the segregation of the contaminated steel product at the port of detection and allow only the contaminated material be returned to the country of origin while retaining the non-contaminated material for use in the importing country;
- The concerned national regulatory authority should advise on the packaging of the contaminated material, as per the IAEA regulations for the safe transport of radioactive material, before the return of the contaminated material to the country of origin and issue the necessary regulatory clearances to enable the return of the radioactively contaminated material;
- The concerned national regulatory authority of the country of origin of the contaminated material should issue the necessary regulatory clearances to enable the return (import) of the radioactively contaminated material;
- Concerned authorities of ports through which the shipment of the contaminated material has to pass should issue prompt clearances for transit stops;
- Denials of shipments of radioactively contaminated material by the shipping carriers should be taken up with the International Maritime Organization and shipping carriers should be made aware of the fact that an empty freight container having contained radioactively contaminated steel material is not hazardous and can continue in use with safety.

If such an action plan were taken up at the international level, the problem of inadvertent radioactive material in scrap metal would be controlled and managed effectively.

7. CONCLUSION

Radioactive contamination is undesirable in steel consumer products. The main cause of radioactive contamination of steel products is the presence of radioactive material in the metal scrap that is collected by the scrap recycling industry. Generally, the radiological hazard from such contamination is very low. However, such contamination problems can have significant economic impacts in the industry. Therefore, it is necessary that all stakeholders take appropriate measures to prevent such incidents. Concerned professional associations/bodies can play a great role in helping all the stakeholders in the steel recycle industry to prevent such undesirable events. An action plan to tackle the problem at the international level needs to be considered. At the same time, it is desirable that a harmonized standard for acceptance of contamination in steel products should be developed for the benefit of each country.

MADAGASCAN EXPERIENCE IN MANAGING THE CONSEQUENCES OF AN INCIDENT WITH CONTAMINATED SCRAP METAL

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Abstract

In May 2007, two containers containing scrap metal were identified as being contaminated with radioactivity at the international seaport of Madagascar. The level of radiation at the surfaces of the containers was relatively high. This paper describes the management of the consequences of this incident in order to provide protection of the workers protection and the environment.

1. INTRODUCTION

The use of techniques in which ionizing radiation is used is subject to specific national regulatory systems that include strict control measures. Law No. 97-041 on protection against the harmful effects of ionizing radiation and radioactive waste management was promulgated on 2nd of January 1998 [1]. Four decrees to implement the law were approved by the Government in 2002 [2, 3]. According to these decrees, the Department of Radiation Protection and the Department of Radioactive Waste Management of the Institut National des Sciences et Techniques Nucléaires (Madagascar-INSTN) is responsible for providing the functions of the Technical Body of the Regulatory Authority.

Customs services are working in collaboration with Madagascar-INSTN to ensure that the import and export of radiation sources is properly regulated. Border workers and custom officers have been trained by Madagascar-INSTN on radiological risks, protection techniques and on the identification of radioactive packages. These precautions have helped to improve the national capability for preventing the import and export of radioactive sources. To aid detection, a container scanner was installed in 2006 at the international seaport of Madagascar in order to detect the presence of radioactive materials.

2. MATERIALS AND METHODS

Mobile screening equipment (type HVC-Mobile) was installed in 2006 at the international seaport of Madagascar. This apparatus is designed for rapid deployment and the speedy inspection of trucks and containers. In addition, a radiation meter of type THERMO ESM FH 40G-L10 Ω (capable of measuring radiation dose rates of up to 100 mSv/h), is used by the border workers to identify suspected contaminated goods.

The Madagascar-INSTN uses a radiation meter of type GRAETZ Dose Rate meter X 5 DE (with an integrated dose rate alarm threshold) for confirming the presence of radioactive materials. In addition, a portable spectrometer EXPLORANIUM GR-135-THE IDENTIFIER can be used for identifying radionuclides present in any contaminated shipments.

In May 2007, border workers and the customs officers detected an abnormal radiation level while two containers containing scrap metal waste to be exported to India were passing through the container scanner. This latter gave the alarm indicating ‘high radiation’. The border workers checked the radiation level around the containers and it was confirmed that the radiation level was significant. As the Technical Body of the Regulatory Authority, the Madagascar-INSTN was immediately informed of the incident. A radiation protection and waste management team was sent to manage the situation. The exporter was also informed of the event.

Radiation dose rate measurements around and at the surface container were carried out by the staff of Madagascar-INSTN. It was confirmed that the radiation level was significantly higher than the acceptable limit for the transportation of excepted packages [4]. The results of the measurements are shown in Table 1. The two containers were isolated within the seaport area.

After detecting the radioactive material at the bottom of the two containers, the radiation protection and waste management team discovered that a lightning conductor containing a radium-226 source was present in each of the two containers. Radiation dose rate measurements were performed at the container surface before and after removing the radioactive materials. The results are shown in Table 2. The radioactive materials were isolated and the radiation levels at the surface and at one meter from the sources were measured. The results of the radiation dose rate measurements are shown in Table 3.

3. RESULTS AND DISCUSSION

The maximum dose rates measured by the Madagascar-INSTN team at each surface container are given in Table 1.

FIG. 1. Container screening using HVC-Mobile.

FIG. 2. Radiation dose rate measurement.

TABLE 1. RADIATION LEVEL AT THE CONTAINER SURFACE

Container identification	PCIU: 387 265/0	PCIU 379 046/5
Radioactive nuclide detected	Radium-226	Radium-226
Maximum dose rate at container surface (μSv/h)	23	40
Limit for transportation of excepted package (μSv/h) [4]	5	5

According to para. 516 of the Regulations on the Safe Transport of Radioactive Material [4], the radiation level at any point on the external surface of an excepted package shall not exceed 5 μSv/h. As maximum dose rates at the container surfaces were 23 μSv/h and 40 μSv/h, it is clear that these containers should not be shipped as accepted packages. The following recommendations were given by the Madagascar-INSTN for the management of the consequences of the incident with contaminated scrap metal:

- The contaminated scrap metal located at the container bottom should be removed before exporting the scrap metal;
- After removing the radioactive material, contamination checks should be performed before shipment.

TABLE 2. RADIATION LEVEL BEFORE AND AFTER REMOVING THE RADIOACTIVE MATERIAL

Container identification	Dose rate at the container surface before (μSv/h)	Radionuclide detected	Dose rate at the container surface after (μSv/h)	Acceptable limit (μSv/h) [4]
PCIU 379 046/5	40	Radium-226	0.09	5
PCIU 387 265/0	23	Radum-226	0.08	5

TABLE 3. RADIATION LEVEL AROUND THE ISOLATED RADIOACTIVE MATERIAL

Radiation dose rate	Surface (μSv/h)	At 1 metre (μSv/h)
Source 1	1036	10
Source 2	590	4

After removing the radioactive material from the containers, the radiation dose rate at the surfaces of the two containers were respectively 0.09 and 0.08 μSv/h – well below the acceptable limit. Figure 3 shows the radioactive material after removal from the container.

As radiation level close to the isolated radioactive material is significant, the next step was the design of interim safe storage for the material.

The Madagascar-INSTN has issued the following recommendations for the safe storage of the radioactive material (considered to be radioactive waste):

- The radioactive waste should be stored in a safe place;
- According to the regulations in force in Madagascar, radioactive waste should not be removed unless authorization is given by the Regulatory Authority.

The radioactive material was duly stored at a safe location as an interim measure.

The root causes of this incident were the lack of recognition of materials that may be radioactive by those involved in collecting, handling and exporting scrap metal. The origin of the scrap metal containing the radioactive material is unknown. Those concerned with the collection of the scrap metal and the loading

FIG. 3. Isolated radioactive material (lighting conductor with radium-226 source).

of it into the containers might have been exposed to radiation but level of radiation dose that might have been received is unknown. Some financial implications may have resulted for the exporters as the containers could not be shipped while containing radioactive materials.

As the incident occurred only a few months after installing the container screening equipment, nothing is known of the history of radioactive material in scrap metal in Madagascar before this time.

4. CONCLUSION AND LESSONS LEARNED

The experience gained from this incident can be used to improve the arrangements for managing such events in future. The national system for the prevention of radiological risks in the recycling metals can be listed as follows:

— Availability of radiation detection equipment at the border to identify suspected contaminated goods to be exported or imported;
— Trained customs officers and border workers in radiological risks and protection techniques and instrumentation for the measurement and analysis of radiation;
— Collaboration between Customs and the Regulatory Body ensures that the potential inadvertent import and export of radiation sources is properly regulated;
— Existence of a national regulation on radiation protection, waste management and transportation of radioactive materials.

The most significant action to be addressed in the future is the radiation control of scrap metal at both national and international levels.

In this case, the exporter was not aware of the radiological risks associated with contaminated scrap metals. For this reason, a radiological training and information programme for companies involved in export and import of scrap metal can be very valuable.

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EXPERIENCES IN MONITORING AND DEALING WITH RADIOACTIVITY IN RECYCLING STEEL AT OUTOKUMPU TORNIO WORKS

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Abstract

Since 2006, two americium-241 sources have been unintentionally melted at Outokumpu Tornio Works resulting in the closure of the melt shop and unplanned production stops. The aim of this report is to outline the experiences in monitoring and dealing with radioactivity in recycling steel. The current monitoring regime at Tornio Works is described, a short description of the incidents that have occurred is given and the emergency preparedness measures that are in place to deal with such incidents are elaborated. Finally, the planned improvements to the monitoring and emergency preparedness measures based on the experiences obtained from the accidents are described.

1. INTRODUCTION

Outokumpu is a global leader in stainless steel production. Its customers include a wide range of industries. Being fully recyclable, maintenance free, as well as a very strong and durable material, stainless steel is one of the key building blocks for a sustainable future.

Outokumpu Tornio Works is located in Northern Finland, and it is one of the world's largest stainless steel mills. The main products coming from Tornio are cold rolled and hot rolled austenitic stainless steel coils and sheets. Ferritic grades are also being produced. The Works is the world's most integrated single site operation; the integrated production process starts at the neighbouring Kemi chromite mine and the Tornio Works harbour where scrap metal is received, and ends the in hot rolling mill and cold rolling lines.

Tornio's annual production capacities are: 1.65 million tonnes of melt, 1.6 million tonnes of hot rolled steel and 1.2 million tonnes of finished general stainless products from the cold rolling mills.

The inclusion of radioactive materials and contaminated items in metal scrap has become a problem of increasing importance. Radioactive sources out of regulatory control, often called 'orphan sources', are regularly found in recycled metal scrap [1]. The majority (62%) of the contaminants are naturally occurring radioisotopes, the remainder are sealed radioactive sources (13%) and unidentified radioactive materials (25%) [2]. The melting of orphan sources occurs often in the steel industry which is an issue for Outokumpu Tornio Works.

2. MONITORING

Based on the reported finds in scrap metal [1] it is clear that orphan sources often end up in scrap metal. Such sources include caesium-137, cobalt-60, americium-241, strontium-90, radium-226 and iridium-192. Additionally, naturally occurring radioactive material (NORM), mainly isotopes of radium and thorium, is also found. This is most often accumulated in scale inside pipelines from industry.

At the Outokumpu Tornio Works, scrap monitoring systems have been used routinely since 1994. This reflects customer requirements for 'radioactivity free products' as well as protection of the workers. The monitoring system in use at Tornio Works is made up of different instruments broadly consistent with the recommended approach of the IAEA for detecting radioactive material at borders [3]. The instruments at Tornio Works can be divided by type as:

- Fixed, installed, automatic instruments designed to be used at monitoring stations where the environment can be controlled. Such instruments can provide high sensitivity monitoring of continuous processes;
- Pocket-type instruments, which are small, lightweight instruments used to detect the presence of radioactive materials and to inform the user about radiation levels (these are available, but not mandatory);
- Hand-held instruments with greater sensitivity (than pocket instruments) used to locate and identify radioactive materials.

At the Tornio Works scrapyard are there is a wide array of hand-held instruments for locating and identifying radioactive materials. However, the main emphasis is on the fixed instruments. There are 17 fixed monitoring stations at different locations in the works area. The approach taken is one of multi-phased radiation control, where all metal scrap will be checked for radioactivity at least twice before smelting. The radiation control in the smelting process (Fig. 1) occurs at: entry of scrap to site, entry to scrapyard and, additionally according to scrap grade, on loading of scrap to melt transporters or the shredder. The monitoring station locations are given in Table 1.

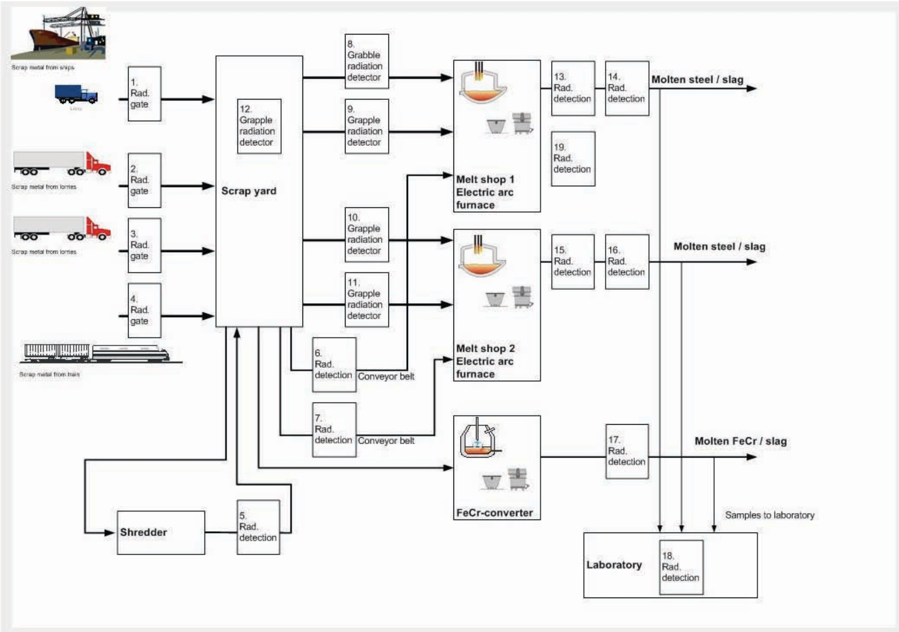

FIG. 1. Scrap processing at Tornio Works prior to smelting.

3. INCIDENTS

Since 2006, two unintentional meltings of americium-241 orphan sources have occurred at Tornio Works. The sources entered the smelting process from the radioactive scrap metal yard, which means that they passed through two or more monitoring stations without being noticed.

The first melting occurred on 25.11.2006 and the second one on 30.10.2007. Details of the accidents are given in Table 2 [4, 5]. The chemistry of molten radionuclides is quite well understood and researched and provides a starting point for any investigations/procedures under accident conditions. While melted cobalt-60 sources will readily alloy with steel and caesium-137 sources will evaporate and escape with the furnace exhaust, americium-241 is easier to manage, as it will be mainly contained in the slag, with a small partition going into dust. The two described incidents resulted in 150 t of contaminated slag and 600 t of contaminated foundry dusts. The disposal arrangements at an industrial landfill are currently being worked out with the national regulator STUK. The disposal costs are not the only costs resulting from the melting accidents; it has been determined that the costs due to the decontamination of process equipment and unplanned production stops have already amounted to hundreds of thousands of Euros.

TABLE 1. MONITORING STATIONS AT TORNIO WORKS

	Type of monitor	Location
1	5× 50 l plastic scintillators	Harbour portal monitor
2	12× CsI scintillators	Weigh station portal monitor
3	6× 25 l plastic scintillators	Weigh station portal monitor
4	5× 25 l plastic scintillators	Train Weigh station portal monitor
5	1× 25 l plastic scintillators	Shredder monitoring station
6	1× 33 l plastic scintillators	Alloy transport monitor 1
7	1× 33 l plastic scintillators	Alloy transport monitor 2
8	2× 3 l plastic scintillators	Grapple monitor
9	2× 3 l plastic scintillators	Grapple monitor
10	2× 3 l plastic scintillators	Grapple monitor
11	2× 3 l plastic scintillators	Grapple monitor
12	1× NaI scintillators	Grapple monitor
13	1× NaI scintillators	Molten steel and slag monitoring
14	1× NaI scintillators	Molten steel and slag monitoring
15	1× NaI scintillators	Molten steel and slag monitoring
16	1× NaI scintillators	Molten steel and slag monitoring
17	2× NaI scintillators	Molten FeCr and slag monitoring
18	1× NaI scintillators	Automatic slag sample measurement in laboratory
19	1× CsI scintillators	Slag sample measurement

TABLE 2. DETAILS OF THE TWO ACCIDENTS [4, 5]

	Accident 1, 25.11.2006	Accident 2, 30.10.2007
Radionuclide	Am-241	Am-241
Contaminated slag (t)	~100	~50
Slag max activity (Bq/kg)	230 000 ± 18 400	100 000 ± 60 000
Contaminated foundry dust	~400	~200
Foundry dust max activity (Bq/kg)	400 ± 80	450 ± 50

4. EMERGENCY PREPAREDNESS

When a sealed source ruptures or melts, contamination spreads into the shredder, mill or foundry equipment, the final product, air, air filters, slag and other by-products. Apart from the already mentioned costs associated with source melting accidents, there is also a potential health hazard to employees and the general public. To limit the associated hazards and to be prepared for any such accidents, Outokupu Tornio Works has emergency preparedness measures in place. The emergency preparedness procedures are part of the safety handbook, which is updated continuously.

The emergency preparedness procedures cover the alarms at the monitoring gates, at the shredder, at the grapple monitors, and in the melt shop. The procedures outline the tasks of the 'duty manager' and the duties of the different employees. These duties include the cessation of the smelting, collection and separation of the final product, slag, foundry dust and other by-products, use of personal protective equipment (PPE) and contacting the appropriate in-house personnel and authorities. The emergency preparedness procedures are listed in Table 3.

5. FUTURE IMPROVEMENTS

The further improvements at Outokumpu Tornio Works are mainly associated with the monitoring systems. Currently there are no planned changes to the emergency preparedness procedures, but these are visited regularly when safety handbooks are revised.

TABLE 3. OUTOKUMPU TORNIO WORKS EMERGENCY PREPAREDNESS PROCEDURES

Procedure	Contents
TJtSät001	Basic information about radiation
TJtSät002	Radiation safety
TJtSät003	Radiation safety contact list
TJtSät005	Portable radiation monitors
TJtSät006	Grapple radiation monitoring test procedures and user guide
TJtSät007	Procedures for an alarm at melt shop
TJtSät008	Procedures for an alarm at grapple monitor
TJtSät009	Procedures for an alarm at seosainekuljettimella
TJtSät010	Procedures for an alarm in melt after EAF
TJtSät011	Follow up procedures after melting of a radioactive source

Monitoring systems for scrap metal are problematic due to the shielding properties of the scrap itself. For instance, in order to detect a cobalt-60 source in a shielded container with a dose rate of the order of 10 μSv/h at the surface, buried in a metal scrap load 1 m thick, with a detector situated about 2 m from the source (minimum distance in case of portal monitors), the monitoring system must be able to detect an increase in dose rate of some 60 nSv/h, equivalent to approximately half of the normal background. For caesium-137 it would be 20 nSv/h — less than 20% of the background [2]. For americium-241 sources the dose rate is not distinguishable. The problem is further aggravated by the phenomenon of vehicle background suppression. If a loaded vehicle enters the monitoring portal, the natural background will be reduced by 10–30% as the vehicle and scrap load block some of the environmental radiation. When the scrap load contains a source which increases the normal background by 30%, the detector signal may be the same as before without the vehicle. To discount this effect, there are plans at Tornio Works to assess the possibilities of suppressing the background around a fixed portal monitor by using 60 t of shredded scrap metal landscaped with low activity stone from the Kemi mine. In addition, today's typical 'portal monitors' have the added benefit of sophisticated software for dynamic scanning with continuous background trend analysis to compensate for the vehicle background suppression. Outokumpu Tornio Works is cooperating with detector manufacturers to improve the current systems.

There have also been significant developments in the sensitivity of detection since the introduction of LaBr3:Ce and LaCl3:Ce scintillators and CdZnTe, HPGe, HPXe semiconductor detectors. In assessing the capabilities of these new types of detectors, the aim is to obtain a system, which is capable of detecting an americium-241 source and of withstanding the stress that monitors are subjected to (mechanical stress and temperature stress). The developments in measuring technology are also being assessed for grapple monitors; the aim is to obtain a system that can distinguish radiation energies below 60 keV. The best results so far have been obtained with NaI and CsI-detectors, but their durability is still a question mark.

In relation to the portal monitors, vehicle speeds are being assessed and how to limit them on unmanned monitoring stations. There is a significant difference in detection capabilities between when a vehicle is moving with a speed of 5 km/h or 10 km/h.

Possibilities for further monitoring developments are also being assessed for the foundry dust monitoring. The aim would be to provide real time measurements of foundry dust activity arising from the smelting process.

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EXPERIENCE IN MANAGEMENT OF INCIDENTS WITH CONTAMINATED SCRAP METAL IN SPANISH INDUSTRIES

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Abstract

This paper describes the lessons learned from one of the incidents involving the melting of a radioactive source in a steel processing plant. The reasons for the failure of the site surveillance system are analyzed and proposals for improvement are made.

1. INTRODUCTION

The metal processing company, at which an incident involving a sealed source being melted occurred, was the Siderúrgica Sevillana, S. A. The company had subscribed to the national *Protocol for Collaboration on the Radiation Monitoring of Metallic Materials*. It operated and maintained a surveillance and control system, with a radiation portal monitor and a spectrometer for checking the radioactive content of processed steel. It had specialized technical personnel for radiation detection.

The incident occurred on 7 December 2001. It involved the melting of a ^{137}Cs source of 100–150 GBq. For the cleanup operations, an authorized company was engaged — supervised by a technical radiological protection unit (UTPR). The amount of waste generated was 340 m^3 and the facility shutdown period while decontamination work proceeded was 30days.

The radiological consequences were small and individual doses were much less than 1mSv/y but the costs to the Company were large. The costs were about 3 million euros; this includes facility decontamination and waste management, but does not include the costs of lost production.

2. CRISIS MANAGEMENT

The situation was totally new and unknown to the Company. There was a need to make decisions very quickly about unusual matters. Subsequently, it was seen as the worst time in the company's existence but it brought about the beginning of a new era of great improvements.

The following lessons emerged from the early period of the incident (the first day):

(a) The need to know what is happening. For this purpose it is necessary to have:
  - A suitable surveillance system;
  - The correct interpretation of the information;
  - External expert help.

(b) The need to know the magnitude of the incident:
  - Obtain information on the affected areas;
  - Based on this, weigh up the situation and engage the necessary resources;
  - Introduce protection measures;
  - Stop the exit of waste from the steelmaking process.

(c) The need to isolate the affected areas to avoid unnecessary risks.

(d) The need to decontaminate and cleanup in the shortest time possible.

3. ANALYSIS OF POSSIBLE CAUSES OF THE INCIDENT

- Possible surveillance system failure? But this did not happen.
- Was the surveillance system adequate? It was confirmed as being suitable.
- Other alarms not responded to? No other alarms occurred.
  - The melting occurred during the cleanup of a scrap stockyard, therefore the source might have been at the back of the yard for an undetermined period of time. This was, in fact the case.
  - Conclusion: the radioactive source was in the stock before the surveillance system was implemented in 1999.

4. PROBLEMS WITH THE INITIAL SURVEILLANCE SYSTEM

- The Spanish Protocol did not initially require the installation of a control system for the exhaust gases in the facility. It considered that radioactivity would be detectable the processed steel.
- The Company installed voluntarily, and in an experimental way, an exhaust gas sensor. The first level alarm was fixed by the supplier at 50 mSv/h.
- It was this sensor that warned the Company about the melting.

— After the event, the sensor was substituted by a more efficient detector that warns above 1 μSv/h.
— The spectrometric analysis of the steel did not show a significant increase in the activity (<0.1 Bq/g).
— The surveillance system has been strengthened with a scrap check during the transfer to the furnace. Its advantage is that it is able to check a smaller amount of scrap (truck <25 t, octopus crane <8t).

5. FINAL CONSIDERATIONS FROM OUR EXPERIENCE OF THE SPANISH PROTOCOL

— The Spanish Protocol has demonstrated its ability to adapt to unexpected situations.
— After the various experiences in Spain, the compiled knowledge has reduced the likelihood of 'unexpected' situations.
— Spanish steel covered by the Protocol offers an added value as a product due to its guaranteed radioactivity security.
— The processing of naturally occurring radioactive material (NORM) in steel plants must be included within the Protocol
— The steel industry needs to clarify the exemption levels concept to face the market.

INCIDENTS IN SPANISH INDUSTRY: LESSONS LEARNED

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Abstract

This paper describes a number of incidents involving the detection of radioactive materials which have occurred at Spanish steel plants in the period since the Protocol came into effect. The incidents illustrate the procedures followed in Spain for their management and the interaction of the government organizations and private companies as a result of the Protocol. The lessons learned from the incidents and the resulting changes brought about in procedures are described.

1. INTRODUCTION

The incident involving the smelting of a radioactive source at the Acerinox facility (Cadiz) in 1998 underlined the need to establish a series of preventive measures to be implemented by those involved in the smelting of metallic materials, in order to prevent the reoccurrence of events of this type. This gave rise to the Protocol for collaboration in the radiological surveillance of metallic materials, which defines the rights and obligations of the signatories.

The implementation of the Protocol has significantly reduced the number of incidents involving the smelting of radioactive sources. The radiological surveillance applied to metallic materials prior to their smelting has led to the detection of a large number of radioactive sources. Nevertheless, since the Protocol was signed, there have been several events involving the smelting of radioactive sources.

The first incident in which a radioactive source was incorporated into the process following the signing of the Protocol occurred in 2001 at the factory of Siderúrgica Sevillana. Subsequently, in 2003, there were events involving radioactive contamination at Daniel González Riestra and Acería Compacta de Bizkaia; in 2004 there were events at Sidenor Industrial Reinosa and Arcelor Alambrón Zumárraga, and finally, in 2007, there was another incident at Sidenor Industrial Reinosa.

2. SIDERÚRGICA SEVILLANA (DECEMBER 7th 2001)

On Friday December 7th 2001, while a batch was being processed in furnace 1 at the Siderúrgica Sevillana S.A. plant located in Alcalá de Guadaira (Seville), the alarm of the beacon type radiation detector located on the smoke dust collection line was activated. The values measured by the equipment ranged from 50 to 60 μSv/h and were slightly higher than the alarm level, which was set at 50 μSv/h. Following confirmation of the alarm, in accordance with the established procedures, a gradual shutdown of the processes of the steelyard was initiated and a series of measures was adopted to identify the causes of the radioactive contamination and its consequences.

The measurements performed by the personnel of the facility led to the conclusion that the batch was not contaminated and that there were radiation levels in excess of the natural background level at certain points on the smoke line and especially in the steelyard's dust collection silo. As a result, the decision was taken to remove the dust from the silo and store it covered with lime in a pit in the steelyard. On finding that the radiation levels had decreased appreciably in the area of the silo, that the detector that had produced the alarm was indicating stable values approximately ten times lower than the alarm trip value and knowing that the contaminated dust had been removed from the silo, the management of the facility decided to restart the steelyard.

On Monday December 10th, a sample of the dust that had been transferred to the pit was analyzed using the spectrometer for the analysis of radioactivity in batch samples. The following day, and in view of the doubts that existed regarding interpretation of the results, the steelyard technicians contacted the National Company for Radioactive Waste Management (ENRESA), which sent its Radiological Protection Technical Unit (RPTU) to the steelyard and also advised them to inform the regulatory body, CSN.

On December 12th, after having received the notification from Siderúrgica Sevillana indicating that there had been a radiation alarm trip at the steelyard and that the cause was being analyzed, the CSN contacted the manager of the facility and requested the results of the analysis of the sample of smoke dust. In view of the results, CSN informed the installation that the smoke dust analyzed was contaminated with caesium-137 (2738 Bq/g) and concluded that a source of caesium-137 had been smelted. This diagnosis was later confirmed by the technicians sent to the site by ENRESA, who performed a preliminary radiometric survey of the installation.

In parallel to the above, the CSN informed the authorities, issued a press release, dispatched an inspection team to the steelyard and activated the Environmental Radioactivity Laboratory of the University of Seville, which is part of the CSN's network of sampling stations (REVIRA-REM).

On December 13th, having evaluated the information provided by the facility and by the inspector sent to the steelyard, the CSN recommended that the company shut down the furnace and proposed to the Ministry of Economy that Siderúrgica Sevillana S.A. be required to draw up an action plan to adopt whatever radiological protection and materials management measures might be necessary to decontaminate the steelyard and safely manage the radioactive waste arising from the operations. The CSN document specified that the action plan should require at least the following activities:

- Adoption of measures necessary to prevent the dispersion of the radioactive material and to limit the amount of waste generated as a result of the incident;
- Radiological characterization of the steelyard;
- Radiological control of the workers in the area of the steelyard that had been contaminated or had been in contact with contaminated materials;
- Drawing up of a plan for the cleaning and decontamination of the areas of the steelyard that had been contaminated;
- Segregation, isolation and radiological characterisation of all the waste materials that would be generated, in the operations deriving from the incident and the cleaning and decontamination tasks;
- Establishment of an agreement with ENRESA for management of the radioactive waste;
- Reporting to the CSN on all actions taken;
- Establishment of adequate technical support for the performance of all the activities, in particular that of an RPTU authorized by the CSN.

In the following days, the CSN observed that between 10th and 12th of December 8 trucks had left the Siderúrgica Sevillana facility for the La Vega recycling and compost production plant in Alcalá del Río (Seville) with approximately 135 tons of inert steelyard dust. The dust had been unloaded on two clearly identifiable fronts in a tip used only for the disposal of this type of inert waste. The tip was decontaminated under the supervision of a RPTU to a level below 0.5 μSv/h, for which it was necessary to remove some 283 tons of radioactive material.

The cleaning and decontamination operations on the smoke removal line of the steelyard were completed on January 9th 2002. After verifying and evaluating the results achieved, the CSN authorized the firing of the furnace. The recovery operations in the rest of the areas affected by the event (inertisation plant and pit initially used to house the contaminated dust) continued until the end of January 2002.

The event had no repercussions for the steelyard workers, since the presence of caesium-137 was not detected in any of the internal contamination measurements performed on the 24 workers who had carried out activities in the area or with contaminated materials. All of the technicians who participated in the decontamination tasks were classified radiation workers; the collective dose received during the activities amounted to 6270 person-μSv.

All the measurements and analyses of samples taken outside the steelyard showed that there had been no contamination outside the facility, with the exception of the tip at Alcalá del Río, which was decontaminated. Likewise, the results of the measurements led to the conclusion that the steel and slag produced in the batch in which the source of caesium-137 was smelted were not contaminated.

As a result of the incident, 553 tons of radioactive waste was generated, this being sent to the El Cabril radioactive waste disposal centre in 28 transport operations. The volume of waste amounted to 372.25 m^3 with an overall level of activity of 98.47 GBq (2.7 Ci) of caesium-137.

This incident underlined the capacity of the beacon type radiation detector installed in the smoke dust removal system to provide an immediate alert in events involving the smelting of a relatively significant source of caesium-137. However, the incorrect interpretation of the data provided by the detector and of the results of the analysis and additional measures led those responsible for the steelyard not to initiate the actions contemplated in point 6.1 of the Protocol for this type of situation. In summary these are: to interrupt the process, suspend the dispatch of material off site, request the services of a RPTU and notify the CSN. The delay in adopting all these actions led to the generation of more radioactive waste and to the contamination of a facility other than the steelyard.

The lessons learned from this event have been made available to the installations that have signed the Protocol via the tracking commission and several subject specific working sessions.

3. DANIEL GONZÁLEZ RIESTRA (AUGUST 11TH 2003)

On August 11th 2003, a truck loaded with wadding (light refuse from the scrap fragmenting process) activated the radiation alarms of the portal monitor at the exit of the facilities of Daniel González Riestra, a company involved in scrap fragmentation and recovery — located in San Andrés de los Tacones, Gijon (Asturias). The personnel of the facility determined that the cause of the alarm was not any particular part of the load but the overall load. They later realized that the fragmented scrap and various materials from the fragmenting machine were contaminated.

The installation shut down the fragmenting facility and notified the CSN, which recommended that the area be signposted and cordoned off and that a RPTU be contacted. On August 12th, the RPTU that had been sent to the installation estimated that the crushed scrap contaminated with caesium-137 amounted to approximately 200 tonnes. The radiation dose rates measured in contact with the scrap ranged from 70 to 400 µSv/h. Contact dose rates on the fragmenting machine ranged between 100 and 200 µSv/h.

On August 13th, two CSN inspectors were sent to the facility, accompanied by ENRESA personnel. The radiological measurements carried out indicated the presence of radioactivity in certain piles of scrap, in part of the fragmenting facility and below the conveyor belts. This led to the conclusion that a source of caesium-137 had been incorporated into the process and fragmented. In parallel with the above, the CSN required the company to adopt certain measures to prevent dispersion of the contamination, control whatever trucks might have transported the contaminated scrap and identify those persons who might have been affected by the incident. The CSN also informed the authorities, issued a press release and checked the readings of the Radioactivity Alert Network in the Principality of Asturias.

Subsequently an action plan was required for the decontamination and cleaning of the facility. This was similar in its scope and acceptance criteria to the one applied in the case of Siderúrgica Sevillana. The objective was to re-establish normal conditions at the facility and to adequately manage the radioactive waste finally produced.

On September 26th, the fragmenting facility was started up, following the decontamination and cleaning work performed; the recovery interventions were completed in 2003.

The event had no repercussion on the workers at the facility since no caesium-137 was detected in any of the internal contamination measurements performed on the workers. All the technicians that participated in the decontamination work were classified radiation workers and no dose above the detection level was registered, except in one case, where a dose of 110 µSv was recorded.

As a result of this incident, a total 52 tons of radioactive waste was sent to the El Cabril disposal facility in five transport operations; these corresponded to a total waste volume of 73.5 m^3. The overall activity amounted to 7.64 GBq (210 mCi) of caesium-137.

This incident underlined the need to increase the awareness of the recovery sector and train it adequately on the measures to be taken in the event of radioactive material being detected in scrap. During the initial inspection by the CSN it was noted that prior to the event, from 4th to 11th of August, the portal monitor had issued several radiation alarms, without the CSN being notified. It is significant in this respect that on August 7th the entrance portal monitor of another steelyard alarmed in response to a truck of scrap from Daniel González Riestra. Following appropriate segregation actions, a source of caesium-137 of approximately 169 mCi (about 6 GBq) was isolated and identified and later removed by ENRESA.

This event also underlined the need for recovery plants using fragmenting machines to have detection portal monitors at the entrance to their facilities, as required in the CSN Safety Guide 10.12 'radiological control of scrap recovery and recycling activities'. These portal monitors should be operated by suitably trained personnel.

The lessons learned from this event have been made available to the installations that have signed the Protocol via the tracking commission and several subject specific working sessions. Likewise, a video on the incident has been published and was presented at the meeting of the Group of Experts of the United Nations Economic Commission for Europe (UNECE) on the monitoring of contamination in scrap, held in Geneva from 5th to 7th April 2004.

4. ACERÍA COMPACTA DE BIZKAIA (SEPTEMBER 15TH 2003)

On September 15th 2003, a truck loaded with steelyard dust activated the radiation alarms of the exit portal monitor at the installations of the steelyard Acería Compacta de Bizkaia (ACB), located in Sestao (Vizcaya). In compliance with the commitments taken on by signing the Protocol, the facility isolated the truck and analyzed a sample of the steelyard dust transported in the truck using the two spectrometers available at the facility for batch testing. These analyses showed the presence of caesium-137 with an activity of around 12 Bq/g, which indicated the possible smelting of a radioactive source. As a result, the plant was shut down, the area was evacuated and isolated and the dose rate measured in the smoke path. The company also alerted its RPTU and reported the event to the CSN.

On the same day, the 15th, and after receiving the notification, the CSN sent an inspection team to the facility and required ACB to adopt a series of measures to prevent the dispersion of radioactive contamination and guarantee the radiological protection of people, the facility and the environment. The characterization operations were monitored by the CSN inspector sent to the steelyard, who was accompanied by inspectors of the Basque Government. These measures were similar to those required in previous events. In parallel to the above, the CSN informed the authorities, issued a press release and initiated the procedure established in the Assignment Agreement signed by the CSN with the

Regional Government of the Basque Country for radiological surveillance in that Autonomous Community.

The radiological controls carried out by the CSN inspection team identified the presence of radioactivity in one of the steelyard dust storage silos, in the extraction line leading to this silo and in the truck leaving the steelyard. The dose rate values measured in the radiological characterisation of the facility (0.1–1.3 μSv/h), along with the value obtained from the sample of steelyard dust removed from the truck, led to the conclusion that a low intensity source of caesium-137 had been smelted. The prescribed recovery measures were completed such that the facility was able to be restarted on September 23rd.

The event had no repercussion on the workers at the facility, since no caesium-137 was detected in any of the internal contamination measurements performed on the workers. All the technicians that participated in the decontamination work were classified radiation workers and no dose was registered above the detection level.

As a result of this incident, 80 tonnes of radioactive waste was generated and sent to the El Cabril disposal facility in five transport operations; these corresponded to a waste volume of 74.8 m^3. The overall activity amounted to 1.75 GBq (47 mCi) of caesium-137.

This incident underlined the fact that the beacon type radiation detector installed in the smoke dust removal system does not provide satisfactory results in the case of a source of low or moderate activity. It was seen however that having the truck loaded with steelyard dust pass through the portal monitor of the facility was a highly efficient measure.

The lessons learned from this event have been made available to the installations that have signed the Protocol via the tracking commission and several subject specific working sessions. The Protocol Technical Working Group has drawn up a revision of the Technical Annex to the Protocol to modify the procedure for action in the event of situations created as a result of contamination due to the dispersal of radioactive material at the facility.

5. SIDENOR INDUSTRIAL FACTORY AT REINOSA (MARCH 24th 2004)

On March 24th 2004, a truck loaded with steelyard dust activated the exit portal monitor radiation alarms at the installations of the steel company Sidenor Industrial, located in Reinosa (Cantabria). In compliance with the commitments taken on by signing the Protocol, the facility isolated the truck and analyzed several samples of the steelyard dust transported in the vehicle using the spectrometer available for batch testing. These analyses detected the presence of caesium-137 with an activity of around 80 Bq/g, which indicated the possible smelting of a radioactive source. As a result, the plant was shut down, evacuated and the area isolated and the dose rate was measured in the smoke path. The company also alerted its RPTU and notified the CSN of the event during the afternoon of that day.

During the morning of the 25th, the CSN decided to send an inspection team to the installation and required it to adopt a series of measures aimed at preventing the dispersion of radioactive contamination and providing for the adequate radiological protection of people, the facility and the environment. These measures were similar to those required in previous cases. In parallel to the above, the CSN informed the authorities, issued a press release and checked the readings of the Radioactivity Alert Network equipment located in Cantabria.

The radiation measurements carried out by the CSN inspection team identified the presence of radioactivity in one of the steelyard dust storage silos, in the extraction line leading to this silo and in the truck leaving the steelyard. The dose rate values measured in the radiological characterization of the facility, along with the value obtained from the sample of steelyard dust removed from the truck, led to the conclusion that a source of caesium-137 of low intensity, although somewhat higher than that of the source involved in the ACB incident, had been smelted.

On March 26th, after having analyzed and assessed the results of the radiological characterisation of the steelyard, the CSN required Sidenor Industrial — Reinosa Factory to draw up an action plan for the cleaning and decontamination of the installations that had been contaminated.

On March 31st, after having carried out the work specified in the action plan, including the emptying and decontamination of the smoke dust collection silo, Sidenor requested permission from the CSN to startup the furnace. Following analysis of the results from the samples of smoke dust, it was decided that a series of additional tasks was necessary — for the cleaning of the smoke transfer lines and the replacement of the sleeves with the highest dose rate readings.

On April 2nd, the furnace was restarted for testing and, on April 5th, after assessing the activity concentration results for the smoke dust generated after 31 batches, the CSN authorized the facility to initiate normal production activities.

The event had no repercussion on the workers at the facility, since no caesium-137 was detected in any of the internal contamination measurements carried out on the workers.

As a result of the incident, 76 tons of radioactive waste was generated, with an activity of approximately 3.03 GBq (82 mCi). The transport of this waste to the El Cabril disposal facility was carried out during the month of June.

This incident, which was similar to the one that occurred at ACB, once again underlined the advisability of having trucks loaded with steelyard dust pass through portal monitors at the exit from the installation. During this incident, new action procedures were put into practice between the company, the Ministry of Industry, Tourism and Trade and the CSN in order to speed up the administrative arrangements to be adhered to in this type of incidents; this arose from the lessons learned from previous events.

6. ARCELOR ALAMBRÓN ZUMÁRRAGA (MAY 31ST 2004)

On May 31st 2004, a truck loaded with steelyard dust activated the portal monitor radiation alarms at the installations of a company involved in the extraction of zinc and lead from such dust. Following this detection, the company returned the truck loaded with the dust to the Arcelor Alambrón Zumárraga steelyard, located in Zumárraga (Guipúzcoa), from where it had come. On its arrival, the truck passed through the steelyard entrance portal monitor, where the alarm was confirmed.

In compliance with the commitments taken on by signing the Protocol, the facility isolated the truck and analysed a sample of the steelyard dust that it transported and concluded that it contained caesium-137. In view of this, the company shut down the plant and carried out a radiological characterization on it, requesting the support of a RPTU and notifying the CSN. The first results obtained from the samples of steelyard dust analyzed gave values of between 1.42 Bq/g (sleeve filter) and 11.71 Bq/g (tanker truck leaving the installation). This led to the conclusion that a low activity source of caesium-137 had been smelted.

After receiving the notification, the CSN required the facility to adopt a series of measures aimed at preventing the dispersion of radioactive contamination and guaranteeing the adequate radiological protection of people, the facility and the environment, and decided to send an inspector to the installation to perform a detailed assessment of the situation. These measures were similar to those required in previous events. In parallel to the above, the CSN informed the authorities, the Basque Government and ENRESA and issued a press release.

During June 1st, the RPTU completed the radiological characterisation of the facility. The characterisation operations were monitored by the CSN inspector sent to the steelyard, who was accompanied by inspectors of the Basque Government.

The CSN assessed the information provided by the facility and by the Council's inspector at the steelyard and concluded that there was no need for additional cleaning and decontamination work at the facility since all the values obtained from the smoke dust line were lower than the acceptance criteria established for this type of incident. As a result, the actions to be carried out within the framework of the cleaning and decontamination plan were to focus on the trucks loaded with the dust from the contaminated steelyard. On June 2nd, the Ministry of Industry, Tourism and Trade required Arcelor Alambrón Zumárraga S.A. to draw up an action plan on radiological protection and materials management measures to decontaminate the trucks loaded with contaminated steelyard dust and to safely manage the waste resulting from these operations.

On the same day, June 2nd, after emptying the smoke dust collection silo, the CSN granted the steelyard a provisional permit for startup of the furnace as part of the activities to be performed to return to a normal situation. Finally, on June 3rd, the CSN granted permission to the steelyard to initiate normal production after having analysed the results from the steelyard dust generated in the first batches.

The event had no repercussion on the workers at the facility, since no caesium-137 was detected in any of the internal contamination measurements performed on the workers.

There was no need to transport radioactive material to the El Cabril disposal facility since the concentration of the samples of steelyard dust analysed following removal from the tanker trucks was in all cases below 10 Bq/g.

The lessons learned from other incidents relating to the procedures for action between the company, the Ministry of Industry, Tourism and Trade and the CSN were put into practice during this incident. This allowed the time taken for the steelyard to return to normal to be reduced.

Despite the lessons learned from the previous incidents at ACB and Sidenor Industrial Reinosa, the facility had not incorporated the need to monitor steelyard dust at the exit of its installations in its procedures. This led to radioactive material being detected at another facility that might have been contaminated if it had not had an entrance portal monitor. Furthermore, the company involved in managing the steelyard dust, which was not party to the Protocol, returned the truck instead of immobilising it at its facility, with the subsequent risk that an accident might have occurred during the return journey to the steelyard.

As a result of the lessons learned from this incident, a circular was drawn up requiring all steelyards to monitor smoke dust and resulting by-products to the extent possible, and the Protocol tracking Commission was urged to initiate measures aimed at having companies in charge of managing steelyard dust adhere to the circular.

7. SIDENOR INDUSTRIAL REINOSA (MARCH 22ND 2007)

At 11:34 hours on March 22nd 2007, the alarm of the portal monitor radioactivity detectors at the weighing platform were activated in response to the exit of a tanker truck transporting steelyard dust.

The personnel of the Sidenor Industrial Reinosa facility took five samples of dust from the truck, as well as samples from inside the facility. These were analysed in the facility's gamma spectrometer used for batch testing analysis. The result was as follows:

- The samples from the immobilised truck were shown to contain specific activity levels of between 1.8 and 6.5 Bq/g of caesium-137;
- In the new collection silo (i.e. the load following the contaminated truck) the values of the different samples taken were between 1 and 1.5 Bq/g;
- No radioactivity was detected in the old silo or cooler;

The plant managers notified the CSN emergency room of the event and of the results of the samples taken, also pointing out that they were continuing their production activities and isolating the smoke dust generated with specific activity values in excess of 1 Bq/g.

The CSN sent a fax to the facility indicating that, in accordance with the Protocol on the surveillance of metallic materials, they should shut down the installation as a preventive measure in order to obtain all the information required for adequate radiological characterisation of the facility, which should be performed by an RPTU. The CSN also indicated that a Council inspection team would visit the facility the following day to perform a more detailed assessment.

A RPTU team, contracted by Sidenor, made up of a supervisor, a technical expert in radiological protection and a radiological protection technician arrived at the facility at 7 a.m. The team held a meeting with the personnel of the facility, who informed them of the measures taken up to that time. The experts in radiological protection concluded that the possible contamination of the facility would be in the smoke filtering system, since the problem was a source of caesium-137, and that it would not have reached the sleeve filters or the old silo, since these elements were isolated at the time.

On completion of the radiological control of the facility, and in the presence of the CSN inspector, a meeting was held during which the personnel of the steelyard and the RPTU presented the information available. The fundamental aspects dealt with during the meeting were as follows:

- No contaminated products or materials had left the facility because intensive controls were put into place since the moment of detection;

— A radiological study was made of the areas through which the smoke purification system runs. This study determined that values in excess of 0.50 μSv/h were not registered at any point of the facility except the lower zone of the new silo, where a maximum value of 1.10 μSv/h was recorded;
— The truck in which the presence of radioactive material was confirmed had been located in an area where there was no risk of the dispersion of radioactive material, since the vehicle in question was a tanker. The otorized part of the truck left the facility and the trailer was parked inside the cordoned area in order to prevent access to it. The maximum dose rate value in contact with the tanker was 3.60 μSv/h.
— The initial radiological control was completed with the analysis of different samples, both from the different elements of the installation and from the tanker that had generated the alarm. The most significant results were registered in hoppers 1 and 2 of the new sleeve (19.1 and 16.9 Bq/g respectively) and in the new dust collection silo (17.5 and 16.3 Bq/g). In the rest of the system, the maximum value encountered was 3.0 Bq/g.

Following the analysis and assessment of the information collected, the CSN required the facility to draw up an action plan for the cleaning and decontamination of the affected installations and vehicle.

At 01:00 hours on March 24th, the furnace was startedup for smelting. During the night, the silo was emptied by the personnel of the facility and the dust generated was collected in ‘big-bags’. The results of the radiological control of the ‘big-bags’ were sent to the CSN for analysis and assessment. Following this assessment, the CSN sent a communiqué authorising the facility to continue with normal production activities.

The event had no repercussion on the workers at the steelyard, since no caesium-137 was detected in any of the internal contamination measurements performed on the workers.

As a result of the incident, 26 810 kg of radioactive waste was generated, with an activity of approximately 0.457 GBq (12 mCi) and a volume of 24.82 m^3. Transport of this waste to the El Cabril disposal facility was performed in two operations during the month of September.

This incident, which was similar to the one that occurred at the same facility in 2004, once again underlined the advisability of having trucks loaded with steelyard dust pass through portal monitors on exiting the installation, as well as the importance of informing the CSN of events as soon as possible, in order to minimize the generation of radioactive waste.

ACCIDENT INVOLVING THE MELTING OF A ^{137}CS SOURCE AT A STEEL WORKS IN MEXICO

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Abstract

On 20 June 2008, the National Nuclear Safety and Safeguards Commission (CNSNS) was notified by the firm Mexico Steel Tubes PLC (TAMSA), based in the state of Veracruz, of the presumed radioactive contamination of steelworks powders from its smelting process. This incident was detected because TAMSA produces casting powders that are sold to the firm National Zinc in the state of Nuevo León. National Zinc received a shipment of these steelworks powders and detected the presence of radioactive material in its radiation portals, for which reason it returned the shipment. TAMSA contracted a firm to monitor the shipment and the presence of radioactive material was detected, for which reason the CNSNS was notified. The CNSNS made various inspections to determine the origin of the contamination and found that a ^{137}Cs source had inadvertently been melted in TAMSA's facilities. Consequently, steelworks powders and subproducts of the firm National Zinc were produced weighing around 2000 tonnes with concentrations of up to 544 130 Bq/kg.

Whole body counts were performed on a total of 130 persons involved in the incident but no internal contamination was found. In addition, samples were taken from environmental strata in and around the TAMSA and National Zinc facilities but no ^{137}Cs contamination was found. It is estimated that the source which was melted was approximately 185 GBq (5 Ci). Currently, the CNSNS is discussing, together with the firms, the strategy for managing, conditioning and storing the contaminated powders, since we do not have a final disposal site for radioactive waste in Mexico.

1. DESCRIPTION OF THE ACTIVITIES

Pursuant to the official notification received by the CNSNS regarding the presumed presence of steelworks powders contaminated with radioactive material, a reconnaissance inspection was made on 8 July 2008 to the facilities of TAMSA (used for the manufacture of steel tubes) and dose rates of up to 57 μSv/h were found (background: 0.1 μSv/h) in the silo area. Samples were taken from various areas and analysed in the CNSNS laboratory. Up to 401 500 Bq/kg of ^{137}Cs were found in the steelworks powder under the collection silos for steelworks powders. It was also found that TAMSA was temporarily storing steelworks powders (prior to sale) at a location in its plant. In the heaps accumulated, ^{137}Cs concentrations of up to 5426 Bq/kg were found. The investigation indicated that TAMSA had melted a ^{137}Cs source of approximately 185 GBq (5 Ci) around the first 5 days of June 2008.

A second inspection revealed that the steelworks powders from the silos had ^{137}Cs concentrations of up to 1427 Bq/kg.

As a result of the sale of contaminated powders, the firm National Zinc detected a load of approximately 200 tonnes of steelworks powder which was to go into its process. However, owing to the detection of the radioactive material, the material was returned to TAMSA. The results of the analyses showed that the steelworks powders contained up to 544 130 Bq/kg of ^{137}Cs.

To check that there was no internal contamination of workers at the plants; inspections were ordered involving whole body counting to determine the presence of internal contamination. A total of 130 persons were examined. None had internal contamination.

Samples were also taken from environmental strata in and outside the facilities of both plants. No ^{137}Cs contamination was found.

The licences issued to TAMSA by the CNSNS authorizing it to use and possess radioactive sources, including 10 ^{137}Cs sources, were audited. All the sources were physically present at the facility.

Powder filters used in the process were analysed. The filters were stored in cardboard boxes after it was suspected that there might be radioactive contamination. The boxes with the process filters were found to contain ^{137}Cs.

The CNSNS instructed TAMSA to send samples from its process to check the concentration levels. The behaviour of the concentration levels is shown in Figs 1 and 2.

A survey was conducted of the radiation levels in the area where the goods waggons are located that were sent back by National Zinc and contain steelworks powders. The goods waggons were properly covered with canvas and inside a properly cordoned off safety perimeter. TAMSA staff were requested to expand the cordoned off perimeter as the dose rates at the edge were approximately 15 times higher than the natural background radiation. The cordoned off perimeter was moved to a distance where the dose rates were approximately 3 times the natural background.

The CNSNS also required National Zinc to send samples from its process to check the concentration levels. The behaviour of the concentration levels is shown in Figs 3 and 4.

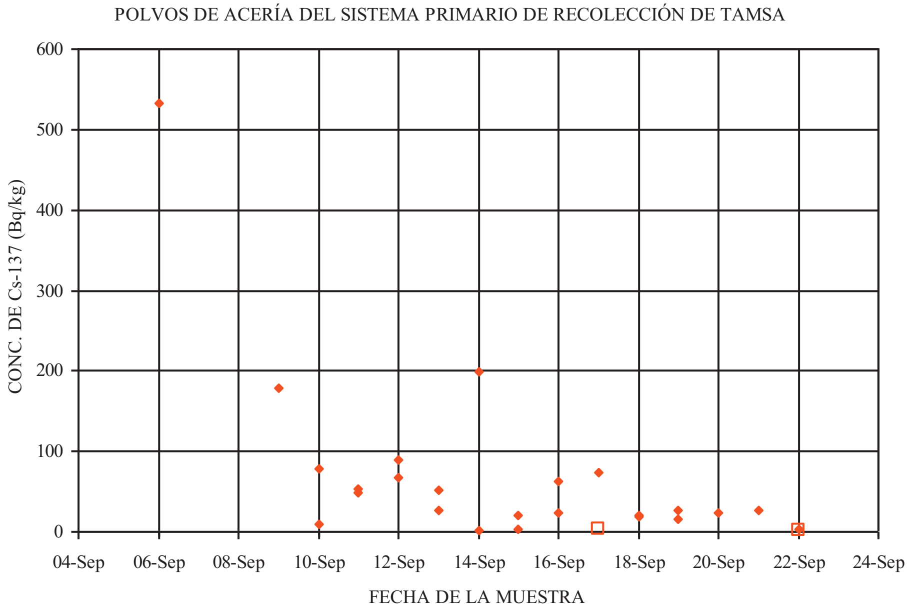

FIG. 1. ^{137}Cs concentrations in steelworks powders during September 2008.

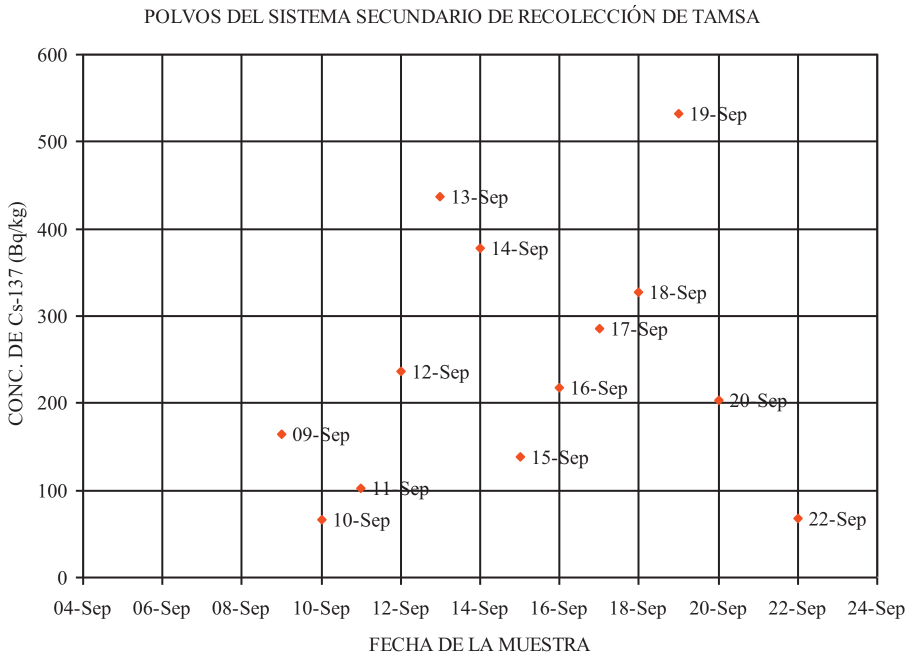

FIG. 2. ^{137}Cs concentrations in steelworks powders during September 2008.

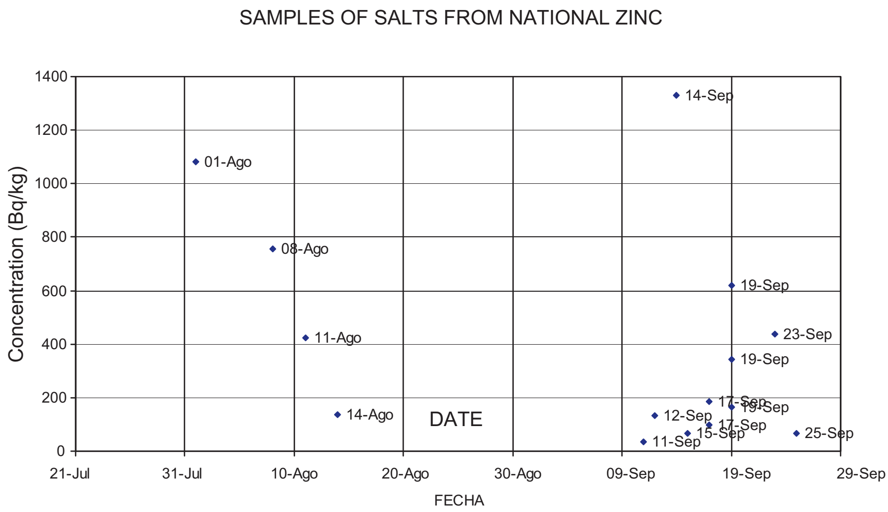

FIG. 3. ^{137}Cs concentrations in samples of salts from National Zinc.

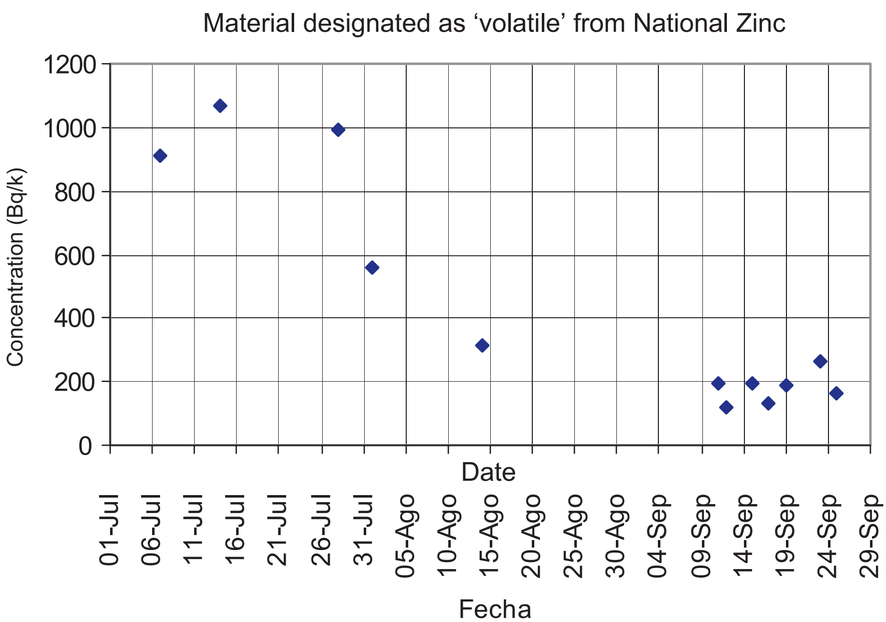

FIG. 4. ^{137}Cs concentrations in samples of material from National Zinc.

2. SHIPMENT SENT TO EUROPE

The CNSNS received a notification on 12 August 2008 from the Belgian Federal Agency for Nuclear Control (FANC) indicating that a shipment of 20 containers (20 tonnes each) had been received from Mexico in which the presence of radioactive material had been detected. An analysis of samples taken from the containers indicated the presence of ^{137}Cs with values of up to 36 000 Bq/kg. As a result, the FACN notified the CNSNS that the shipment was to be returned to Mexico. The CNSNS investigated the origin of the shipment and found that it was product from the firm National Zinc, and so this firm was required to indicate all potentially contaminated shipments that had been offered for sale. National Zinc indicated that there were another 400 tonnes of the same batch of material that were to be exported to China but the load was still in a Mexican port, and so it was required that the shipment be detained and the material not offered for sale. The material that was to be offered for sale to China was returned to the facilities of National Zinc, and on 23 October 2008 the material from Belgium arrived which was transferred to the facilities of TAMSA. It should be noted that the material TAMSA received is subproducts (powder) different from the steelworks powders.

National Zinc reprocessed the material intended for China employing a dilution/concentration process where, in each process batch, radioactively clean material is mixed with contaminated material. One of the subproducts of National Zinc's industrial process is a mixture of zinc sulphate, lead carbonate, cadmium, potassium chloride and sodium chloride. According to the information provided by National Zinc (which was checked by CNSNS staff), the caesium is concentrated in the chloride salts, which comprise 2% of the material obtained.

3. ACTIONS REQUIRED OF TAMSA

To resolve and mitigate the consequences of the radioactive contamination, the CNSNS has required, inter alia, the following of TAMSA:

— An Action Plan that would result in the control of all the material produced or derived in connection with the melting of the ^{137}Cs radioactive source;

— The Action Plan in question must take account of the fact that, as there is no adequate containment to store the products, subproducts and other contaminated items, they will be stored at TAMSA's facilities for a period of at least 10 years, and the storage conditions must be such as to prevent dispersion, dilution and contamination of the surroundings;

— The accumulated powders must be placed in heaps in super sacks;

— All the material must be characterized;
— A facility must be set-up in which all the contaminated material will be kept. This facility must meet the applicable requirements of the General Radiation Safety Regulations and Mexican standards in this field.

To achieve the foregoing, TAMSA was instructed to perform these activities with the help of the National Nuclear Research Institute who have, to date, submitted a work plan comprising two stages: the first involves the management, characterization and storage of the contaminated material and the second stage involves the processing of the contaminated material to reduce its volume. This project is planned to last approximately 1 year.

4. CURRENT STATUS OF MATERIAL

The material is contained in a section of the TAMSA site. There are 3 types of location:

— Material stored in the open air covered with canvas (approximately 1200 tonnes);
— Material returned by National Zinc contained in goods waggons covered with canvas (approximately 80 tonnes);
— Material returned by Belgium contained in super sacks in ISO type containers (400 tonnes).

The arrangement of the zones is shown in Fig. 5.

Figures 6 and 7 show the location of the TAMSA and National Zinc plants

5. CONCLUSIONS

Given that there has not been an accident of this kind in Mexico, various aspects were identified that still need to be resolved:

— There is no regulatory framework in this field. In this regard, the CNSNS has initiated steps to sign a cooperation agreement with firms which use scrap with a view to the appropriate identification, reporting and management of radioactive material in scrap, and appropriate action in the event of inadvertent melting;

FIG. 5. Current location of the material inside the TAMSA site.

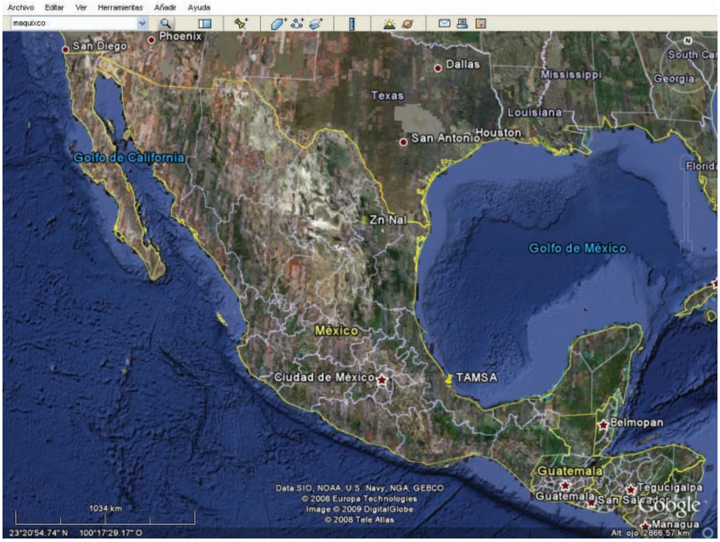

FIG. 6. Location of the TAMSA and National Zinc plants.

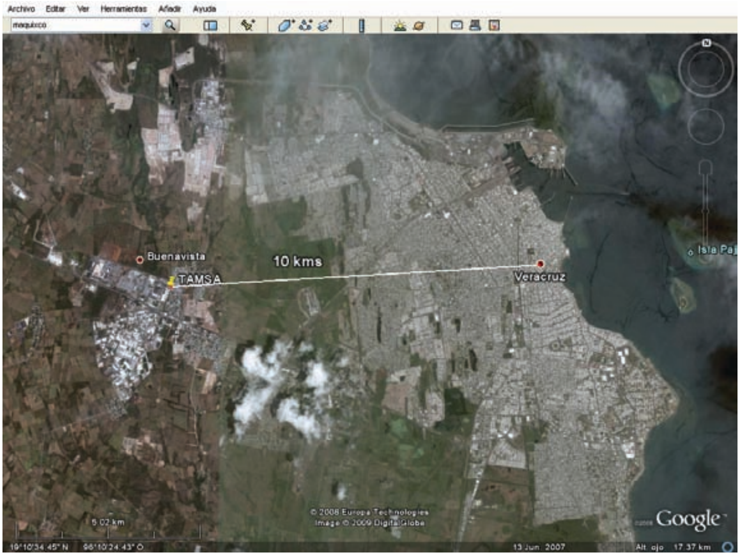

FIG. 7. Location of the TAMSA plant

- There is no final disposal site for radioactive waste in Mexico. Thus, the CNSNS is taking appropriate steps to establish a site for this type of material. In addition, it is being proposed that the volume be reduced so the material can be stored at the temporary storage site for radioactive waste run by the National Nuclear Research Institute;
- Owing to the lack of regulation in this field, National Zinc took the decision to reprocess the contaminated material;
- There is no established minimum concentration for exempting contaminated radioactive material. In this connection, TAMSA, through the National Nuclear Research Institute, will submit a value for management of the contaminated material;
- Finally, the CNSNS has established that there is a need for links with industry in this branch, and cooperation with other Secretariats of State, such as the Economy Secretariat which is the competent body in this field, to carry out coordinated measures, including being able to dictate timely shutdowns of plants to reduce the generation of contaminated material.

HUNGARIAN PRACTICE AND SOME TYPICAL CASES

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Abstract

Although the use and disposal of radioactive materials is regulated by the Government, many cases occur where radioactive sources or radioactive materials are discovered in scrap metal. This paper describes the arrangements for detecting and managing incidents in Hungary and the lessons learned from recent experiences.

1. INTRODUCTION

In Hungary, there are usually five to ten incidents in a year and most of them are regarded as typical cases. About 40% of the extraordinary events happen at metal recycling facilities before the source reaches the smelting process. A special detection system, a monitoring gate, is needed to detect the radioactive sources in scrap metal. The main locations where radioactive materials are discovered are steel plants and border stations where radiation detecting systems or radiation measuring equipment are in use. Typical types of radioactive scrap that can potentially reach the recycling process include discarded industrial gauges, metal pieces or components covered with radium paint, radioactive alloys and naturally occurring radioactive materials in scale coated tubes with enhanced activity concentration.

2. MONITORING SYSTEMS

There are 36 monitoring gates at Hungarian border stations, 11 gate monitors at metal recycling facilities and a few gates at electronic companies. The detector systems are usually of NaI or full plastic systems. The places where the radiation detecting systems are located in Hungary were examined last year. The monitoring systems were tested and the results were summarized in cooperation with the Hungarian Atomic Energy Authority. For testing, a very simple measurement approach was used; an alarm warning by a simple Co-60 test

FIG. 1. Gate monitor.

source was employed. The results show that the systems give an alarm signal at 150% of the background level. These systems are outside of the responsibility of the Radiohygiene Institute and there are no trained and experienced persons at these companies. Therefore, if there is a real alarm, the companies call for the help of the relevant experts or the National Radiohygiene Duty Service (NRDS).

3. NATIONAL RADIOHYGIENE DUTY SERVICE

The NRDS is based in the National Research Institute for Radiobiology and Radiohygiene with a director, a deputy director and six experts. The institute is linked to the Government via the Ministry of Health. The Service is the responsible organization for the control of incidents and the prevention of the other consequences in case of extraordinary radiological events. The Service, operating with the help of other Government organizations, leads and controls the management of incidents when they occur. The Service has a special vehicle with equipment for dealing with source incidents (detector systems, handling equipment, and a decontamination package) and a lead container to transport sources with activities not exceeding 5 GBq Cobalt-60 equivalent activity. National regulations allow NRDS to transport radioactive isotopes, if the radiation dose rate does not exceed 20 μSv/h at the position of the driver. Every

FIG. 2. Radium-226 sources in metal tube.

year training exercises are conducted in which different emergency cases are simulated. Training courses are organized for the Service staff as well as for other organizations, for instance, the police, the fire department and disaster management organizations.

4. EXTRAORDINARY EVENTS

In the last three years, the extraordinary cases included: naturally occurring rasdioactive isotopes in scale on metal tube surfaces, a strontium-90 source in a MI-2 type helicopter, a radium-226 radioactive source from a research institute found at a border control and a caesium-133 stable isotope source found on a person and being used for illegal commercial purposes.

Ten radium-226 radioluminescent sources were found among scrap metal. The shipment was sent back from Bosnia because the measured radiation dose rate on the surface of the transport vehicle was up to 15 μSv/h. This shipment was moved from the metal recycling facility and exported to Hungary without any measurement being carried out on it. Fortunately there was not an accident, but it provides a good example as to why it is necessary to strictly follow the rules.

5. CONCLUSIONS

There were no injuries or accidents in the above mentioned cases but it was probably the involvement of the NRDS that prevented them from occurring.

Problems sometimes occur at metal recyling facilities where there is more than one exit but only one monitoring system at one of the exits.

In the case of the shipment sent back to Bosnia it was recognized that it is necssary to measure at both inward and outward border directions.

Finally, a big question for the NRDS is who pays the costs if the source is taken to the Radioactive Waste Treatment and Disposal Facility and no owner can be identified.

EXPERIENCE OF CONTAMINATED METAL IN FRANCE

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Abstract

On October 7th 2008, ASN was informed that some radioactivity had been detected in metal pieces manufactured by the MAFELEC Company, which manufactures control and signalling devices for harsh environments. This radioactivity was due to the inclusion of cobalt-60 inside the metal used to manufacture elevators push buttons. This paper describes the consequences for workers and the public of this event, the ASN investigations and actions and the international impacts.

1. BACKGROUND TO THE REGULATORY SYSTEM IN FRANCE

1.1. The French Nuclear Safety Authority (ASN)

The Nuclear Safety Authority (ASN), an independent administrative authority set up by Law 2006-686 of 13 June 2006 concerning nuclear transparency and safety (known as the TSN law), is tasked, on behalf of the State, with regulating nuclear safety and radiation protection in order to protect workers, patients, the public and the environment from the risks involved in nuclear activities. It also contributes to informing the citizens.

1.1.1. Duties of ASN

The ASN is in charge of the regulation of civil nuclear activities (large nuclear facilities, installations or activities which use sources of ionizing radiation for medical, industrial and research purposes and transport of radioactive materials). The TSN law confirms ASN in its role as supervisor of nuclear safety and radiation protection and in its duty to inform the public on these matters. It nonetheless continues to work in its four traditional professional areas:

- Production of regulations (proposals to the Government or decisions by ASN);
- Issue or preparation of individual decisions;
- Supervision of activities and installations;
- Information to the public.

The ASN carries out inspections and may pronounce sanctions, up to and including suspension of operation of an installation. The ASN is also responsible for conducting a radiation protection watch (radiological surveillance of the environment and surveillance of exposure to ionizing radiation of workers, etc.). It assists the Government in the event of an emergency.

1.1.2. Organization of ASN

The ASN is run by a board of five commissioners. The board guides ASN thinking on the supervision of nuclear safety and radiation protection, defines ASN general policy and takes the major decisions. The Director General of ASN, under the authority of the Chairman, organizes and controls ASN’s central services and its eleven regional delegations. The ASN workforce is about 400, and its budget amounts to 54 million Euros.

1.2. Regulatory framework

The French regulations concerning the radiation protection of workers and the public are derived from the European Union Council Directive 96/29/EURATOM and are translated into two codes: the Labour Code and the Public Health Code.

1.2.1. Effective dose limits

The exposure of the public and workers as a result of nuclear activities is subject to the following limits: 1 mSv/year for the general population and 6 or 20 mSv/year for workers (depending on the degree of medical monitoring).

1.2.2. Use of artificial radionuclides

The intentional addition of natural or artificial radionuclides to consumer goods and construction materials is prohibited (art. R. 1333-2 of the Public Health Code). Waivers may, however, be granted by the Minister for Health after receiving the opinion of the French High Public Health Council, except with respect to foodstuffs and materials placed in contact with them, cosmetic products, toys and personal ornaments. This new range of prohibitions does not concern the radionuclides naturally present in the initial components or in the additives used to prepare foodstuffs (for example potassium-40 in milk) or to materials used in the production of consumer goods or construction materials. Furthermore, the use of materials or waste from a nuclear activity is also, in principle, prohibited, when they are contaminated or likely to have been contaminated by radionuclides as a result of this activity (art. R. 1333-3).

1.2.3. Absence of a discharge/release threshold

To sum up, although the above mentioned directive 96/29/EURATOM so allows, French regulations have not adopted the notion of a discharge or release threshold, in other words a generic level of radioactivity below which the waste from a nuclear activity can be disposed without supervision. Regulations also do not include the notion of 'trivial dose', in other words a dose below which no radiation protection action is felt to be necessary. However this notion appears in the directive 96/29/EURATOM (as being 10 μSv/year).

1.2.4. Transport

In relation to the regulations for the transport of radioactive materials, French regulations transpose all the international agreements and requirements in force (IAEA TS-R-1 prescriptions, and other related international agreements)

2. EVENT DESCRIPTION

MAFELEC is a factory located near the city of Grenoble that manufactures control and signalling devices for harsh environments, including elevator push buttons.

On September 17th 2008, MAFELEC was informed by its carrier, FedEX, that radioactive materials had been detected in one of its shipments of elevator buttons sent to the United States of America (USA) via Paris international airport.

On October 3rd and 7th, MAFELEC was informed by its US customer that shipments of elevator buttons containing radioactive materials had been stopped by US customs.

On October 7th, following this alert, MAFELEC informed the civil protection department and experts were sent to the MAFELEC facility. After investigation, a significant radiation dose rate inside the workshop was detected. The facility was then closed.

3. ASN FIRST INVESTIGATIONS

On October 8th 2008, ASN performed an inspection of the facility and Institut de Radioprotection et de Sûreté Nucléaire (IRSN) experts — the technical support organisation of ASN — carried out precise measurements to assess the radiation dose rate and to characterize the radioactive materials. The results of these investigations were the following:

- MAFELEC has only one customer: the OTIS company with sites at locations worldwide;
- The radioactive material is cobalt-60 included in the steel;
- These metal parts, assembled with other pieces to manufacture elevators buttons, are supplied by two Indian companies, LAXMI and Bunts Tools Company;
- There was no contamination inside the plant (the buttons are mounted without cutting and shipped to the customer);
- Measurements performed by IRSN identified a radiation dose rate up to 50 μSv/h at one of the MAFELEC workstations.

ASN required IRSN to make a dose rate assessment concerning the MAFELEC workers and asked MAFELEC to organise the removal of the contaminated pieces, to send it the customer listing and to identify the origin of the contamination.

This event was rated level 2 on International Nuclear Emergency Scale (INES) scale (based on the IAEA draft additional guidance for the rating of transport and radioactive source events).

4. RADIOLOGICAL CONSEQUENCES

4.1. MAFELEC workers

The conclusion of the first ‘rough’ assessment performed by IRSN was that three workers had received a maximum effective dose of 2.7 mSv and that 22 other workers had received over 1 mSv (in this case, MAFELEC workers are considered as members of the public and not as exposed workers).

The final IRSN dose estimation, based on MAFELEC final information (precise work periods and percentage of contaminated pieces), was a maximum exposure of 0.9 mSv for eight people.

4.2. OTIS workers

The doses received by these workers were below the annual regulatory limit for the public of 1 mSv.

4.3. The public

IRSN has evaluated the maximum effective dose due to the presence of radioactive buttons in elevators. The maximum dose rate would be 150 μSv a year (5 minutes/day, 300 days/year, at 50 cm from the control panel).

5. ASN ACTIONS

5.1. International cooperation

ASN has closely collaborated with customs organizations and international counterparts, in particular in India (Atomic Energy Regulatory Board, AERB), to identify the origin and the destination of all shipments containing contaminated parts sent from Indian suppliers and to implement appropriate measures.

First, ASN informed by email all regulatory bodies in countries where MAFELEC customers were located.

Secondly, ASN contacted its counterparts in countries where there are customers of the same MAFELEC Indian suppliers.

Close collaboration with Sweden, Belgium and Netherlands permitted ASN to identify a third Indian supplier of contaminated parts, independent of the MAFELEC issue. This third Indian supplier had sent pieces to Sweden and they were held by Dutch customs in Rotterdam port during their transport because radioactivity had been detected.

ASM acted quickly, in cooperation with the Swedish regulatory body (SSM), by sending an information message to the European ECURIE (European Community Urgent Radiological Information Exchange) network. ASN became the unique contact point with AERB in exchanges with its Indian counterpart. ASN also sent information to WENRA (Western European Nuclear Regulators Association) and INRA (International Nuclear Regulators Association) members. Thanks to the information collected by its European counterparts and MAFELEC, ASN was able to collaborate efficiently with the French Customs organization.

After days of investigations performed by AERB and based on inspections and measurements at all Indian suppliers involved in the contaminated parts manufacture sent to France and Sweden, the root causes of the contamination were identified by AERB. Contaminated parts sent to France and Sweden came from the same Indian foundry and the steel melts were clearly identified. AERB produced a report detailing the step measures implemented in India and, inter alia, the location of radioactivity monitoring devices in all the Indian suppliers implicated in MAFELEC metal parts manufacture.

Once the melt numbers were confirmed, most of the contaminated part lots were identified by ASN and MAFELEC and this information was relayed to all MAFELEC customers; including those located abroad.

6. ORIGIN OF THE CONTAMINATION

6.1. Waste management

Concerning the international impact of this event, ASN had to deal with the management of radioactive buttons coming from MAFELEC in foreign countries. ASN considered these radioactive buttons as being waste. Decisions had to be made on who should be considered as the waste producer and to whom the contaminated buttons should be returned — MAFELEC or the Indian companies.

Even if the buttons were considered to be foreign waste and, as such, should have been returned to the Indian company, taking into account the limited volume they represent and the problems that could be caused by their transportation, ASN said it saw no disadvantage to their disposal in France.

6.2. Carrier inspection

On October 10th, ASN inspected the buttons carrier in the Paris-CDG airport.

As a result, it was discovered that radioactivity had been detected in a MAFELEC shipment on September 17th but this information was not signalled to the authorities at the time and the shipment was sent to the USA.

Moreover, another MAFELEC shipment passed in transit through the airports of Lyon (France) and Leipzig (Germany) and was then sent on to the USA, where it was held by the US customs.

On the day of the inspection, another contaminated shipment was located in the cargo zone and was isolated on ASN request.

According to the ASN investigations, more than 700 MAFELEC packages had been shipped by the carrier through the Paris-CDG airport since January 2008. 400 of them were sent to the USA after systematic radioactivity control, and only 2 were identified as being radioactive.

6.3. OTIS

ASN asked OTIS to stop using pieces identified as contaminated. ASN also requested OTIS to identify contaminated buttons that could have been installed, to remove and eliminate them. After the investigation, it was established that less than 2000 contaminated buttons had been installed.

7. APPROVING THE USE OF THE ELEVATOR BUTTONS

Two conditions had to be fulfilled to release the elevators buttons:

— No radioactivity shall be detected in the buttons;
— Since there is no discharge/release threshold in the French regulations, the condition that the buttons shall not belong to the melts concerned by the cobalt-60 contamination, was applied.

On the basis of the IRSN measurements and of the traceability information coming from India, ASN authorized the restart of the manufacturing and progressively granted the clearance of the buttons from MAFELEC. This process took two months and was dependent on the progress of investigations in India.

All buttons that did not comply with the two conditions were sent for radioactive waste disposal.

8. FEEDBACK

8.1. MAFELEC feedback

Change of culture: one of the points raised by this event is that MAFELEC — in common with most of the French metal products manufacturers — had no radiation protection culture before the event. MAFELEC had no radioactivity detectors, and hardly knew what radioactivity is (which explains the alert delay of three weeks, after the first radioactivity detection). As a result of this event, MAFELEC has purchased radioactivity detectors to check every shipment coming in and developed procedures in case of radioactivity detection.

8.2. International cooperation feedback

Cooperation with ASN counterparts abroad was one of the key elements of the management of this event. Information exchange was easy, efficient and fruitful.

However, despite all the information sent to regulatory authorities and to direct or indirect MAFELEC customers, the management of the contaminated parts found abroad was different from one country to another, depending mainly on the local regulatory requirements and on the customer knowledge of radiation protection issues. As this sector of industry does not normally manipulate radioactive materials, basic regulatory requirements were not applied; for example, contaminated parts were sent back to MAFELEC as conventional goods (and held by French customs). Moreover, this event revealed that it is not easy to identify who should be responsible for dealing with contamination materials when they are found: the company which raised the issue, the company where the pieces were originally contaminated or the country where the contamination was found, according to its own regulation?

8.3. ASN feedback

As MAFELEC had no knowledge of radioactivity issues, ASN had to take an unusual position: ASN was not only a regulatory or inspection body, but somehow had to help MAFELEC handling the situation. For example, ASN assisted MAFELEC in the removal and storage of the contaminated parts, in the implementation of procedures put in place in case there was a new detection of contaminated parts, in the transport of contaminated parts found abroad back to France, and in contacts with foreign authorities.

As a conclusion, even if the utility retains the responsibility for the radioactive materials in the same way as ‘normal’ licensees, ASN cannot let this kind of utility handle by itself an unpredictable and unprepared situation. The second point is that, because of the international dimension of this event, many ASN people were involved: staff from the ASN Division in Lyon and from other regional divisions as well (depending on the locations of OTIS facilities in France), from the Department of International Relations, from the Department of Waste and from Department of Transport and Industrial Facilities. Moreover, this event needed a very efficient exchange of information and quick and co-ordinated actions between the different ASN departments.

COBALT-60 CONTAMINATED STEEL IN GERMANY: EXPERIENCES AND FIRST STEPS

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Abstract

This short note presents a current problem being experienced in Germany and other European countries concerning the inadvertent import of radioactively contaminated stainless steel products. The issue is briefly discussed and possible solutions to it are put forward.

1. THE ISSUE

In the last few months the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has observed a marked increase of stainless steel imports contaminated with cobalt-60 to Germany. The levels are up to about 600 Bq/g.

All together, more than 150 tonnes of stainless steel products have been collected by the competent German authorities. Different types of products have been found, ranging from raw material to end products, e.g. elevator buttons, sports equipment, stainless steel cuttings and valves.

Eighty to 90 per cent of the material is contaminated at levels below the German and European exemption level of 10 Bq/g but above the clearance level of 0.1 Bq/g. The source of the contaminated stainless steel has been traced to an Indian smelting plant where it is understood that a radioactive source containing cobalt-60 was melted in June/July 2008. Other countries have been affected by this incident and one of the papers presented at this Conference describes similar events in France.

The steel industry does not accept material with any kind of radioactive contamination even if the levels are below exemption or clearance levels. This is because, inter alia, several German companies have suffered severe economic consequences as a result of incidents of this kind. Besides the high costs arising for storage and disposal, the reputations of the companies can be damaged. In addition, there is a loss of confidence in this industrial sector. For these reasons, the industry protects itself by installing radiation detection systems at the entrances to scrapyards and melting plants in Germany.

2. AVAILABLE OPTIONS

The following options for handling the recovered material in Germany are currently being considered by the affected companies and by the German authorities:

— Melting by a specialized company with a radiation protection licence;
— Return to the Indian producer under the control of competent authorities to prevent a re-entry into the cycle;
— Use in controlled radiation protection areas;
— Storage under control for 20–30 years.

3. ACTIONS BY THE AUTHORITIES

The BMU has taken the following actions:

— Indian authorities have been asked to provide support for a controlled return of the material and enhanced control to prevent further shipments;
— The metal trade associations and concerned companies were informed and invited to discuss the options for handling this topic;
— The public was informed in two press conferences;
— The European Commission (DG-TREN) was informed;
— The issue has been raised at an international conference on the subject (Tarragona Conference).

4. WHAT CAN BE DONE?

What can authorities do? Some ideas are:

— Improve control over high activity sealed sources (HASS);
— Strengthen the execution of the HASS Directive (2003/122/Euratom);
— Urge IAEA to support Member States to reflect the provisions of the Code of Conduct on the Safety and Security of Radioactive Sources in their legislation;
— Harmonize policy in Member States on handling products with activity concentrations in the range 0.1–10 Bq/g;
— Impose stronger controls at borders.

What can industry do?

— Amendment of contracts to agree upon ‘non-contaminated material’;
— Enhancement of ‘Recommendations for Monitoring and Response to Radioactive Scrap Metal’ (UNECE 2006) or broadening of the Spanish Protocol.

IMPROVING CONFIDENCE AND PROTECTING THE INTEREST OF STAKEHOLDERS

(Session 5)

Chairpersons

D.E. KLEIN
USA

J.C. LENTIJO
Spain

Rapporteurs

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SUMMARY OF SESSION 5

IMPROVING CONFIDENCE AND PROTECTING THE INTERESTS OF STAKEHOLDERS

This, the final session of the conference, was focused on the important topic of public perception. The public in most countries is concerned about the hazards of ionising radiation and when there is a risk that radioactive material can be present in close proximity to them, for example, in metal products, that concern becomes magnified. The session contained presentations on the views of the recycling industry, of a national regulator, of an expert in risk perception and communication and of a journalist.

The recycling industry has already worked considerably on the issue of radioactive material in metal scrap and over the years has been in dialogue with various national and international organizations concerned with radiation protection. National solutions are necessary but insufficient, and the international market requires international approaches and solutions considering all the agents involved. The demand from the industry for a certificate to be issued with each load relating to the absence of radioactivity has proved difficult for several reasons - mainly related to the presence in metals of naturally occurring radionuclides. The recycling industry contributes to solving some of the real problems of society and its efforts should be looked upon positively by the Governments and not hindered or paralysed.

In the USA, the regulator has tried on several occasions to introduce general legislation concerned with controlling the release of materials from regulatory control. Despite great transparency in approach, it has failed, mainly because of the public perception that this was a device for releasing radioactive materials to the general environment. At present, a case by case approach has to be used.

People's perception of risk is not generally only 'rational' but also contains 'emotional' elements that depend on a number of factors. Good communications must fully respect the attitudes and evaluations of all the persons/organizations involved in decision making. Some important components in human perception and assessment of risk are:

— Trust in the person issuing the information or performing the action;
— Personal assessment of risk and corresponding benefit;
— Voluntary acceptance versus imposition of the decision;
— Whether the risk factor is perceived as natural or human-made;
— Sensations regarding the pain or suffering that might be received;

— Catastrophic versus chronic nature of the effects;
— Concern about uncertainties; there is more fear of uncertain things.

The media transmits information to the public about events happening in the world. The way in which it does this can obviously affect public opinion. In this sense it performs a public service but it also needs to be successful and therefore it is aware that the nature and form of presentation of 'news' will attract attention and sell its product.

Society will react to the information received in a highly variable manner, depending on numerous factors, among them its perception of anything that might affect its safety. This perception depends on its perception of the level of responsibility and trust associated with the organisation concerned and also the level of trust it has in those issuing the information.

As regards the title of this Conference, which refers to the existence of radioactive material 'inadvertently' found in scrap, it is in itself a factor of social concern that makes it difficult for the public to have 'a priori', a positive perception.

The media itself must form a judgement about the information that it receives and the validity of the information, as regards both day to day activities and in the event of a crisis. The media has to regulate itself and to be responsible. Generally speaking, there are no external regulatory systems for media activities in any country.

THE VIEW OF THE RECYCLING INDUSTRIES

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Abstract

The Bureau of International Recycling (BIR) is an international trade federation representing the world's recycling industry, covering, in particular, ferrous and non-ferrous metals, paper and textiles. This paper sets out the concerns of the worldwide recycling industry about radioactive material appearing in scrap metal. The involvement of BIR over the last decade in the international discussions on this matter is described and the views on the way forward are presented.

1. THE BUREAU OF INTERNATIONAL RECYCLING

The Bureau of International Recycling (BIR) is an international trade federation representing the world's recycling industry, covering, in particular, ferrous and non-ferrous metals, paper and textiles. Plastics, rubber and tyres are also studied and traded by some BIR members.

About 800 companies and national federations from over 70 countries are affiliated to BIR. Together they offer an international forum for industrial exchange and business contacts. The national federations provide their expertise to other industrial sectors and political groups in order to promote recycling.

It is estimated that the recycling industry employs more than 1.5 million people, annually processes over 500 million tons of commodities and has a turnover exceeding 160 billion US$.

BIR members deal with materials that are diverted from the 'waste' stream for the purpose of reuse or recycling. They deal neither with waste disposal (land filling) nor with incineration or composting.

BIR's primary goals are to:

— Promote materials recycling and recyclability, thereby conserving natural resources, protecting the environment;
— Facilitate the free trade of recyclables in an environmentally sound manner.

As a trade organization, BIR offers its members the opportunity to do business together, to learn the latest market developments, to know the best available recycling technologies and to be informed on the international legislative context. Through its Secretariat in Brussels, BIR offers these services to its members.

BIR makes representation:

— Worldwide towards United Nations bodies, for example, the UNEP Basel Convention, and the UNECE;
— Regionally towards the Organization of Economic Cooperation and Developments (OECD) and towards the European Union (EU). However, there are many recycling federations in the EU, amongst which those specifically for metals scrap collection, sorting, processing and trading are:
— EFR — The European Ferrous Recovery and Recycling Federation, located in Brussels, Belgium, was created in 1992 from COFENAF, the Liaison Committee for ferrous scrap within the EEC. EFR members are national associations and federations in EU Member States representing the interests of commercial firms that are primarily involved in the collection, trade, processing and recycling of ferrous scrap. In EU Member States, more than a thousand large companies and Small and Medium Enterprises (SMEs) are represented through EFR;
— EUROMETREC — The European Metal Trade and Recycling Federation, located in Brussels, Belgium was created in 1990 from the Liaison Committee for non-ferrous metals trade within the EEC. EUROMETREC members are national federations in EU Member States representing the interests of commercial firms that are primarily involved in the collection, trade, processing and recycling of non-ferrous metal scrap. In the EU Member States, more than a thousand large companies and SMEs are represented through EUROMETREC.

BIR Conventions are held bi-annually. For example, in the recent past, conventions were held in Beijing (China), Brussels (Belgium), Athens (Greece), Warsaw (Poland), Monte Carlo, Düsseldorf (Germany). Most conventions also have exhibitions where machinery and equipment suppliers show and demonstrate their wares, which often include radioactivity detection systems. The conventions also feature, on a regular basis, Workshops on topics such as trading on the metal exchanges, radioactivity, shipping, etc.

It is important to recognise the inverted pyramid structure of the metals recycling sector as comprised of:

Many Scrapyards:	Small sized
	Medium sized
	Large sized, and the
Few Consumers:	Ferrous and Non-ferrous Metal Works

In October 1998, BIR presented its 'Guide to Radioactivity' to its members in order to explain the basics of radioactivity, to help determine what actions material recyclers should take and to provide an initial contact guide for summoning expert help. The Guide was promulgated together with a survey questionnaire.

2. BIR INVOLVEMENT IN UNECE DISCUSSIONS ON RADIOACTIVITY ISSUES

BIR put forward a 'Formal Position on Radioactivity Issues' in summer 1999 in its submission to the UNECE Workshop on Radioactive Contaminated Metallurgical Scrap (Prague, Czech Republic).

The following is an edited version of that statement.

"BIR speaks as the unified voice of the international recycling industry on a world level, promoting free-trade in non-hazardous recyclables and the increased usage of recycled goods.

BIR members do not trade in radioactive materials and do not wish to receive hazardous radioactive contaminated materials. Furthermore, it is very uncommon to find this unwelcome and unwanted material.

The burden of handling contaminated materials should not rest on the recycling industry alone, however, as the hazards associated with processing contaminated materials are potentially extreme, recyclers have a role to help safeguard both their workforce and subsequent customers.

Some BIR members have invested in in-plant detection equipment of various types from a variety of suppliers to detect contamination from 'lost' sources or from naturally occurring radioactive materials (NORM).

Strict State control on sources in use would be very welcome to limit these 'losses'.

Not all BIR members are in a position to provide or operate detection equipment; therefore, BIR would welcome States providing detection and control at sea ports and at border checkpoints on railways and roads.

Some States have proposed permitting requirements for the handling of radioactive contaminated materials and have tried, inappropriately, to impose on the mainstream recycling industry, permits designed for the specialist decontamination or decommissioning industry. Current discussions on applying the transport of dangerous goods regulations would lead to unnecessary and impracticable additional restraints to facilitating proper disposal. A more reasoned approach would be to draw up a binding code of practice to avoid disincentives to detection and subsequent appropriate action. Free of charge disposal routes would recognize [the fact] that the recycling industry should not have to bear the costs resulting from lack of Government/institutional controls [on Radioactive Products.]

As the mainstream recycling industry never intends to purchase or sell radioactively contaminated metallurgical scrap, provisions to prohibit purchase and sales would not be constructive, and could lead to court actions, furthering disincentives to cooperation.

International understanding of the basic scientific issues needs improvement. A clear distinction must be made between the very specialized decontamination industry and the normal recycling industry that does not want to process radioactively contaminated material.

There is a need to determine and harmonize the standards and measurement techniques for radiation. If a standard for 'below regulatory concern' could be internationally accepted, materials certified as such, would be regarded as normal commercial materials. As detection systems become more effective and sensitive, this is the most important criteria to resolve.

The misunderstanding and misuse of information related to radioactive contaminated metallurgical scrap is of great concern because the recycling industry could suffer from adverse and unfair publicity which would damage cooperation and damage markets for recyclables.

BIR whose members' efforts are directed at environmentally sound materials recycling and the detection of this unwanted material, is providing a service and safeguard to customers and to society as a whole.

BIR promotes international cooperation on the need for a political solution to the problem of 'take back' of materials rejected on grounds of radioactive contamination or, in the absence of proper treatment facilities in the country of origin, the provision of alternate free of charge decontamination or disposal options."

Many of these issues raised by the recycling sector hare been discussed at length in various fora. The most relevant forum for BIR, as a world federation, has been the forum of the UNECE.

The initial result of these many stakeholder discussions was the UNECE elaboration of the 'Report on the Improvement of the Management of Radiation Protection Aspects in the Recycling of Metal Scrap' (2002). The description of the recycling sector in the aforementioned document is still valid as is the explanation of the ways in which radioactivity in scrap occurs. The discussions were difficult in some areas but compromises and understandings were reached. The document also helpfully explained, in its Annex, the Spanish Protocol and, adjacent to that, the International Atomic Energy Agency's (IAEA) Code of Conduct on the Safety and Security of Radioactive Sources.

Leading up to the UNECE publication 'Monitoring, Interception and Managing Radioactively Contaminated Scrap Metal' (2004), BIR participated in the discussions and very much welcomed this follow-up activity which looked in more detail at what countries were doing.

BIR maintains that more countries should be encouraged to adopt activities in line with the Spanish Protocol, and that much can be learned from sharing other project experiences.

However, BIR has concerns over constraining or restricting trade routes to some countries because of there being insufficient detectors at the exits/borders to their countries.

Subsequently, the issue by UNECE of 'Monitoring and Response Procedures for Radioactive Scrap Metal' in 2006, gathered more experiences and showed which the 'frontrunners' are — in terms of countries managing the issues of unwanted radioactivity entering the recycling sector. However, there was some industry concern over the apparent increase in administration promoted by the various certificates, procedures and forms proposed in that document.

From that work of some three years ago, came the smaller pamphlet by UNECE on 'Recommendations on Monitoring and Response Procedures for Radioactive Scrap Metal' (2006). BIR had a little difficulty with the title which was somewhat alarming — possibly implying that 'radioactive scrap metal' is commonplace. In fact it is explained in the introduction that it is a rarity; but the title could lead to misconceptions by the public. However, it seems that the frequency of detection may be expected to rise because more detectors are now in use. BIR expressed concern about the balance in activities and actions recommended to be taken — that is, burden sharing between regulators and industry. To improve the rate of removal of unwanted contaminated materials, incentives for the finder would be most efficient. In contrast, burdens placed on the finder of contaminated metal scrap would be unhelpful and indeed discouraging.

In the subsequent year, 2007, the UNECE published its International Training and Capacity Building Strategy for Monitoring and Response Procedures for Radioactive Scrap Metal. BIR welcomed its approach of starting with a baseline report and analysis of the national situation, and then logically promoting national workshops and the development of national action plans, followed by implementation activities. As regional activities, workshops and capacity assessments and regional implementation strategies clearly would be beneficial to providing solutions.

It is perhaps a pity that the UNECE questionnaire on the Application of the UNECE Recommendations on Monitoring and Response Procedures for Radioactive Scrap Metal was circulated in September 2008, as the financial crisis may have distracted many in the industry from responding. BIR would certainly wish to see further surveys to check on progress and believe the UNECE to be well placed to carry these out and analyse the results.

So from ten years ago, has BIR position changed in 2009? BIR fully acknowledges that the work done by UNECE has been beneficial as a whole and supports most of the activities recommended. After so much has been done at the international level, making further progress now comes down simply to implementation at the national level. There is a wealth of helpful guidance now available and the experiences of well functioning systems in certain countries.

3. POSITION OF THE EFR

BIR has European daughter federations, one of which is EFR, The European Ferrous Recovery and Recycling Federation. EFR had in 1996 agreed with its customers' federation EUROFER on certain specifications for scrap metal - parts of which are described in the UNECE publications. Subsequently, because of legal advice, EFR has had to publish these specifications separately. The following is the new text of these specifications:

"General Conditions applicable to all grades

As is practically achievable in customary preparation and handling of the grade involved

The definitions of this list of specifications apply only to non-alloy carbon steel scrap as raw material for the steel industry.

Environmental, health and safety considerations

A) Safety

All grades shall be checked, within the limitations of accessibility and in strict compliance with appropriate detection equipment for radioactivity, to identify:

- *material presenting radioactivity in excess of the ambient level of radioactivity.*
- *radioactive material in sealed containers even if no significant exterior radioactivity is detectable due to shielding or due to the position of the sealed source in the scrap delivery."*

The lawyers' and insurers' view was that the previous wording requiring that all scrap consignments are 'completely free of radioactivity' would have unsupportable liability consequences. This wording still remains a point of discussion with customers.

4. CONCERNS COMMON TO METAL RECYCLING INDUSTRIES ACROSS THE WORLD

- There is a need to implement good legislation.
  - BIR's preference is to recommend such a voluntary agreement as the Spanish protocol, due to the participants' good experiences with it.
- There is a need to set out responsibilities fairly
  - Governments and society should assist with costs of prevention and detection and response, particularly with the cleanup and disposal of the radioactive material found and, if appropriate, facilitate its return to country of export.

Lastly, the public should be confident that the recycling industry is part of the solution to society's problem in respect of contaminated materials.

THE VIEW OF THE NUCLEAR AUTHORITIES: UNITED STATES NUCLEAR REGULATORY COMMISSION

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Abstract

In order to increase public and stakeholder confidence that public safety is being protected, there is a need for regulatory control and oversight of radioactive material throughout its lifecycle. The USA accomplishes this by having a strong regulatory framework for the use and control of the material, an effective programme for response to incidents and for the recovery of material in the event it is found in the public domain and a process for communication with the public and stakeholders. The arrangements and programmes for achieving this are described in this paper.

1. INTRODUCTION

Radioactive sources are now commonplace throughout the world and are in widespread use in medical practice, in academic research, and in numerous industrial applications, such as gamma irradiation, radiography, gauging, gas chromatography, and well logging. These sources are useful but are also potentially harmful if misused or if misplaced or stolen.

In past years, the metal recycling industry has found itself faced with the problem of radioactive materials becoming inadvertently mixed with recycled metal scrap, posing a challenge to radiation safety regulatory bodies nationally and internationally. There is a need to balance the benefits to the users of the materials, with the need for the public to be confident that the materials will be adequately controlled, accounted for and properly disposed of by licensees. Recyclers of scrap metal can be at risk of suffering health hazards and economic penalties if radiation sources are improperly managed.

In order to increase public and stakeholder confidence that public safety is being protected, there is a need for regulatory control and oversight of radioactive material throughout its lifecycle. The USA accomplishes this by having a strong regulatory framework for the use and control of the material, an effective programme for response to incidents and for the recovery of material in the event it is found in the public domain and a process for communication with the public and stakeholders.

2. COMPONENTS OF THE US REGULATORY FRAMEWORK

In the USA, many federal agencies and the states have important roles in protecting the public and the environment from radiation. The US regulatory approach emphasizes the accountability of the licensees in possession of the radioactive material. The regulatory framework requires licensees to secure and control radioactive material at all times to prevent or reduce the potential for lost or stolen sources. This framework also requires routine inventory checks to ensure early discovery of lost or stolen sources. Timely reporting is also required for lost or stolen sources so that recovery operations may be initiated as soon as possible. Federal, State, and local governments have always worked together to investigate and recover lost or stolen sources. Recovery of excess or unwanted sources is extremely important to the overall protection of public health and safety, the reduction of potential security threats and the prevention of radioactive material from being introduced into scrap metal.

2.1. US Nuclear Regulatory Commission and Agreement States

The primary mission of the Nuclear Regulatory Commission (NRC) is to protect public health and safety and the environment from the effects of radiation from licensed nuclear reactors, sealed sources containing radioactive material, and waste facilities. The NRC has public health and safety regulations in place, and the threat of terrorism has led it to implement additional security requirements that should make radioactive material entering into scrap recycling even rarer.

Thirty-five States have signed formal agreements with the NRC, providing for regulatory responsibility by the States over small quantities of special nuclear material and its sources and by-products. Such Agreement States currently have jurisdiction over roughly three-fourths of the radioactive sources in the USA In these States, the NRC maintains oversight to ensure that the State programmes are compatible with its own programme, but otherwise the NRC relies on the States to ensure the protection of public health and safety.

There are roughly 2.2 million devices (licensed under either general or specific licences) containing radioactive material in use in the USA today. Approximately 22 000 persons or companies are specifically licensed to manufacture and/or use either sealed or unsealed sources. In addition, it is estimated that over 100 000 licensees possess generally licensed sealed sources and devices for specified uses. Medical use is widespread; radioactive materials, as both sealed and unsealed sources, are used in 17 to 19 million diagnostic and therapeutic clinical procedures each year.

In regulating these devices, the NRC and the Agreement States issue specific licences to users to allow the use of certain sources and devices for certain designated applications, such as medical brachytherapy and teletherapy, industrial radiography, product irradiation, well logging, and laboratory research. Specific licences are issued because the types and quantities of radionuclides present in these devices present a greater hazard than the material found in generally licensed devices. The use of specific licences provides a higher degree of confidence that the user is aware and knowledgeable of the requirements; has the training, experience and facility to control the material; and allows for routine interaction with these users to ensure that they maintain appropriate awareness and control. These devices are inspected on a periodic basis and are subject to careful regulatory scrutiny.

The NRC and the Agreement States also issue general licences to users for certain other sources and devices with applications in measuring, gauging, process control, light production, and ionized atmosphere production. There are about 2 million such devices in the USA As noted previously, sources licensed under a general licence are usually smaller than those that are specifically licensed and represent much less risk to health and safety. Persons who receive sources subject to a general licence are required to meet certain regulatory requirements, such as maintenance, transfer, and testing of these sources and devices, but are not subject to the detailed scrutiny that is typical of specific licensees.

The NRC and the Agreement States hold their licensees accountable for the safe use of radioactive material. For example, the NRC conducts an enforcement programme that can include civil penalties and, in egregious cases, even criminal prosecution. This ensures that licensees understand the importance that NRC places on compliance with the requirements. In addition, the NRC has a standard policy where losses of material incur a civil penalty, approximately three times the cost of proper disposal, in order to ensure that the financial burden for abandonment of a source exceeds the cost of proper disposal. This increases the level of confidence that licensees will not pursue inadvertent disposal driven by financial benefit.

Since the gathering and disseminating of information are central to effective control of radioactive sources, the NRC maintains a nuclear materials events database, which contains over 15 000 records of materials events submitted to the NRC from approximately January 1990 to date. The database includes data on orphan sources which, thereby, enables users to search source or device information on found orphan sources. Since this database also includes information on sources previously discovered missing or lost, this increases the possibility of resolving situations where material is found. Also, the database provides an opportunity for the USA to use the information to ensure that the regulatory programme is sufficient to address needs, and to institute any improvements — increasing the level of confidence that the USA is maintaining a strong, workable programme.

2.2. US Department of Energy

A network of programmes has been in place since the early 1990s to deal with orphan and unwanted sources. The network consists of: (1) a Memorandum of Understanding between the NRC and the Department of Energy (DOE) concerning the management of sealed sources, (2) the DOE's Off-site Source Recovery Programme, and (3) the Conference of Radiation Control Program Directors' National Orphan Radioactive Material Disposition Programme. Emergency requests for assistance in recovering orphan sources or sources in imminent danger of becoming abandoned by either the NRC or the Agreement States are handled as emergency source recoveries under the Memorandum of Understanding with the DOE.

Planned recoveries of unwanted sources are also handled by the DOE's Off-site Source Recovery Programme. The programme allows licensees and individuals to register sources for recovery. The Conference of Radiation Control Program Directors assists States and the NRC in the dispositioning of sources by providing information, such as lists of waste brokers, individuals who want sources and those that want to get rid of them. The Off-site Source Recovery Programme has removed more than 17 000 radioactive sealed sources containing more than 189 000 curies of material from over 600 industrial, educational, healthcare, and government facilities across the U.S. since 1999.

2.3. Conference of Radiation Control Program Directors

The Conference of Radiation Control Program Directors (CRCPD) is a professional organization that includes the directors and staffs of regulatory programmes from both Agreement and non-Agreement States. As such, the CRCPD provides a forum for the States to interact with the NRC and coordinate the regulation of radioactive materials. Each State in the USA has one or more programmes to address radiation protection and to respond to and investigate alarms at scrap metal facilities.

The CRCPD worked with officials of the US Environmental Protection Agency (EPA), the DOE, and the NRC, to develop a national system for prompt and economical management of orphan radiation sources and other unwanted radioactive material. The NRC provides funding to support the National Orphan Radioactive Material Disposition Program for safely dealing with the disposition of discrete 'orphan' radioactive material.

CRCPD staff maintains contacts with government agencies and commercial services for on-scene assistance for securing and assessing radioactive material. The CRCPD can assist with finding, and in some cases funding, an outlet for radioactive material or related equipment such as radiation detectors or shielding. CRCPD staff typically respond to each request within one working day, by providing advice, offering contacts for on-scene assistance, or sending forms and information, as appropriate. Where appropriate, CRCPD staff can assist in locating manufacturers and individual licensees that might accept the material, or facilitate DOE acceptance, and will provide other assistance where needed. The CRCPD services are provided to both the general public and regulatory agencies without charge.

2.4. US Environmental Protection Agency

The Environmental Protection Agency (EPA) is the Federal agency responsible for setting air emission and drinking water standards for radionuclides. The EPA has also identified specific areas in which training can help reduce the opportunity for radioactive sources to contaminate the US steel stock or the environment.

Training programmes developed by the EPA have increased the capability of the recycling industry to detect, identify, and remove abandoned sources when they are encountered in scrap metal. State radiation control programme officials and metal processing facilities worldwide are increasingly implementing these programmes.

Additionally, the EPA is cooperating with the United Nations Economic Commission for Europe (UNECE) to develop an international radiation monitoring protocol for lost and abandoned radioactive sources. When implemented, countries will have a framework that allows for consistent trade in scrap metal, while helping to prevent the incorporation of lost, stolen, or abandoned radioactive sources into consumer products.

2.5. US Department of Transportation

The Department of Transportation regulates transport of hazardous materials including radioactive contaminated scrap metal by highway, rail, air, and waterbody. The Department of Transportation is responsible for the design and performance specifications of packages containing small amounts of radioactive material. However, the NRC is responsible for developing the design and performance specifications for packages containing large amounts of radioactive material. The NRC regulates and approves the design, fabrication, use, and maintenance of shipping packages.

3. DISPOSAL OF RADIOACTIVE MATERIAL

Current disposition programmes cover a range of options, including storage, recycling, reconstitution, resale, and, as a final option, disposal as radioactive waste. The ability to dispose of radioactive sources in the US depends on whether the source is a DOE source or sources resulting from certain Federal activities or if it is a commercial source subject to regulation by the NRC or the Agreement States. DOE sources can be disposed of at certain DOE radioactive waste disposal facilities. Commercial sealed sources are disposed of in commercial low level radioactive waste disposal facilities.

4. RELEASE OF SLIGHTLY CONTAMINATED MATERIAL FROM LICENSED SITES

The NRC's existing regulations contain a framework of radiation standards to ensure protection of public health and safety from the routine use of radioactive materials at licensed facilities. These standards include a public dose limit and dose criteria for certain types of media released from licensed facilities, such as airborne and liquid effluents. However, they do not contain a specific dose criterion to be used to verify that solid materials being considered for release have no, or very small amounts of, residual radioactivity. Instead, the NRC's approach is to make decisions on disposition of solid materials by using a set of existing guidelines, primarily based on survey instrument capabilities. Because this approach does not derive from a specific regulation, the NRC's staff provided a draft proposed rule to the Commission for consideration in 2005 that was intended to improve the NRC's regulatory process by incorporating risk informed criteria into the regulations for disposition of solid material.

As part of its decision making for the rulemaking, the NRC staff was engaged in several information gathering activities and actively sought stakeholder participation and input. Activities included requesting public comments, conducting public meetings and reviewing various related reports prepared by recognized national and international organizations. The staff also considered other relevant Federal and international standards in this area. Finally, as part of its information gathering, the NRC completed several technical studies to evaluate alternatives for controlling the disposition of solid materials.

On June 1, 2005, the Commission disapproved publication of the draft proposed rule and deferred the rulemaking for the time being. The Commission's rationale for its disapproval included the fact that the NRC's current approach to review specific cases on an individual basis is fully protective of public health and safety, and that the NRC is currently faced with several high priority and complex tasks. A subsequent petition for rulemaking in July 2007 was denied by the Commission because the issues raised by the petitioner fell within the scope of the Commission's rationale not to conduct rulemaking in the area.

5. COMMUNICATION WITH THE PUBLIC AND STAKEHOLDERS

The final component required for increasing public and stakeholder confidence is communication. It is not only necessary to have a strong regulatory framework, but also to inform and educate the public and stakeholders regarding that framework, and to provide the ability for open exchange or feedback. This open communication allows for both public and stakeholder understanding of the framework, as well as for the framework to be improved by that feedback. This works to increase the efficiency of the framework, to ensure that all aspects are properly addressed, and to respond to any sensitivities or concerns of the public and stakeholders. As a general policy, the USA has open communication, making the majority of its documents and decisions available to the public, primarily via its public websites and through published documents in the US Federal Register. In addition, there is specific targeted outreach to the public and stakeholders. For example, both the NRC and the EPA have websites providing information on orphan sources (http://www.epa.gov/radiation/source-reduction-management/sources.html; http://www.nrc.gov/materials/miau/miau-reg-initiatives/orphan.html).

In addition, the NRC published a poster (NUREG/BR-0108, rev 1; http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0108/) regarding sources, providing basic information on how to identify such material, and what to do if it is found. The NRC actively engaged the scrap, recycling, and demolition industries during the development of the poster in order to ensure that all issues are addressed, and regarding awareness and dissemination of the poster, thus maximizing the effectiveness of the information.

6. CONCLUSION

In summary, radiation sources and devices containing radioactive materials can provide important benefits to individuals and societies when they are properly designed, safely used, and carefully managed. A strong regulatory framework is necessary to provide confidence that material will be properly controlled, preventing radioactive materials from inadvertently being mixed with recycled scrap metal and responding quickly in the event that it does. The US experience suggests that there are several key elements of an effective regulatory programme for radioactive sources. Such a programme should include several interdependent activities: developing an appropriate regulatory system, devoting resources to implementing that system, ensuring accountability and establishing measures to address the loss of control of radioactive sources. A strong regulatory framework and recovery programme combined with open communication with the public and industry will help to promote confidence that any risk of uncontrolled material is being minimized.

PUBLIC CONCERN ABOUT RADIATION: WHY OUR FEARS DON'T MATCH THE FACTS

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Abstract

The problem about radioactive contamination of recycled materials is, at its heart, an issue of perception and emotion. This paper explains how the scientific disciplines of neuroscience and psychology can explain the way we perceive risk and why our fears of radiation and many other risks don't seem to match the facts. Finally, it explains the discipline of risk communication, and its use for addressing the problem of public concern about radiological issues.

1. INTRODUCTION

Turkey, 1998. France and China, 2000. Thailand, 2000. Europe and India, 2008. The list of incidents involving radioactive contamination of recycled metals is growing. As the first generation of nuclear power plants around the world ages and faces decommissioning, the risk of this sort of contamination only increases. And each incident contributes to rising public concern about the danger. That, in turn, threatens to limit our ability to reuse valuable materials, which is a much more sustainable way of behaving in a warming world of limited and dwindling physical resources.

It is important to keep in mind that the actual physical risk from the radioactive contamination of metals and other recycled materials is minimal. Even in the most egregious cases, recycled materials contaminated with radioactive contents expose very few people, if any, to levels high enough to do serious health damage. That is important to remember *not* because it provides what seems like a simple solution to the problem of public fear; merely explain to people that the actual risk is low. No, it is important to remember that the physical risk is low so that people working on this problem can recognize and deal with the heart of the challenge…the high level of fear of ionizing radiation. The problem about radioactive contamination of recycled materials is, at its heart, an issue of perception and emotion. Even if the physical risk is low, if the fear is high, public concern and opposition will be a real problem and must be considered as part of the overall risk management challenge in dealing with radioactive contamination of recycled materials.

2. RISK PERCEPTION

As the scientific disciplines of physics and toxicology and biology can help us understand the physical risks from ionizing radiation, other scientific disciplines — neuroscience and psychology — can explain the way we perceive risk and why our fears of radiation and many other risks don't seem to match the facts. With radiation, chemicals, and new and complicated technologies like genetically modified food, we are often more afraid than the physical risk assessment says we need to be. But with threats like heart disease and stroke and diabetes, even as common a killer as motor vehicle accidents, we are frequently *less* afraid than the evidence suggests we should be. The study of risk perception can explain this 'perception gap' between our fears and the facts. A closer look at what research into risk perception has to tell us about people's fears of radiation can be an important tool in thinking through solutions to the problem of radioactive contamination of recycled material.

The study of how humans perceive risk has found that the process is a combination of rational and instinctive, analytical and emotional, conscious and subconscious. The first part of this system that must be understood is the neuroscience of fear, the physical details of how the human brain is constructed and the biochemistry of how it works. Between the two sides, the subconscious, instinctive, emotional systems have more influence on our perceptions than rational analytical conscious thinking. In part this is because the physical circuitry of the brain causes the areas of the brain associated with fear to fire first when a threat stimulus is perceived. These systems trigger the 'fight or flight' response *before* the parts of the brain that do rational, cognitive, analytical thinking have even received the threat stimulus. After the initial response, the biochemistry of the brain, along with it's physical circuitry, ensure that the subconscious, instinctive, emotional systems have more influence over our perceptions than the rational 'thinking' parts of the brain. So anyone who wishes to understand the perception of ionizing radiation must realize, and accept, that our brain is designed to fear first and think second, and fear more and think less.

(This is a very simplified summary of the findings of Dr. Joseph LeDoux and others, well summarized in LeDoux's book The Emotional Brain, Simon and Schuster, 1998.)

3. RISK PERCEPTION FACTORS

The next field of science that helps us understand why our fears of radiation often exceed the actual danger, is the field of psychology. Study of the way humans perceive risk has identified a set of psychological characteristics of potentially hazardous circumstances that help us judge, quickly and subconsciously, whether there is danger, and how worried, if at all, we should be. There are more than a dozen of these so-called ‘risk perception factors’. Here are several that bear specifically on our fears of ionizing radiation.

— *Pain and suffering*. The greater the pain and suffering from a risk, the greater our fear. Radiation is associated with cancer, widely perceived as a particularly painful way to die, so the risk from radiation is going to evoke more fear.

— *Uncertainty*. People are generally more afraid of things they don’t have the knowledge to understand. This bears on radiation in two ways. First, radiation is invisible and undetectable to the human senses. That means we can’t be aware of the risk in a way that would give us information we could use to protect ourselves. So when we can’t detect a risk, our fear of it is greater.

  The other area in which uncertainty bears on radiation is the uncertainty we feel when we don’t fully understand something. The physical sciences of ionizing radiation are complex and difficult to understand, even for experts. Like other complex hazards that are hard to fully understand, like industrial chemicals or genetically modified foods, ionizing radiation is frightening, in part, simply because it is hard for most of us to fully understand the threat and how it might affect us. That leaves us uncertain, and afraid.

— *Is the threat natural or human-made*? A natural risk, like radon, evokes less fear than the same type of ionizing radiation that comes from a human-made source. This is why comparing human-made radiation to ‘background’ levels often has little effect. The two are not comparable *psychologically*. To a physicist, a gamma ray from a human-made source and a gamma ray from a natural source of the same isotope are the same. To regular people, they are not the same at all.

— *Risk versus benefit*. The greater the benefit, the less we fear the risk. This is why many people who willingly subject themselves to medical radiation still fear nuclear waste.

— *Choice*. A risk that we choose to take, such as when communities offer to host a waste disposal facility or nuclear power plant, is less frightening than the same risk if it is imposed, as the people in Nevada in the USA feel about

Yucca Mountain. If we are exposed to radiation in recycled materials, the risk is being imposed on us by somebody else and it evokes more concern.

— *Control*. The more we feel we can affect events as they occur, the less afraid we will be. This is not a matter of choice, whether to engage in the risk voluntarily in the first place, but how much actual control we feel over what's happening to us. The sense of control we have when we operate a motor vehicle is an example of this perception factor. On the other hand, airborne radiation from a radiological dispersal device or nuclear plant accident feels like something we can't do anything about.

— Is the risk *catastrophic or chronic*? Risks that threaten large numbers at one time evoke more fear than statistically greater causes of injury or death where the victims are spread out geographically and across time. Images of Hiroshima and Nagasaki and Chernobyl associate nuclear radiation with catastrophe. That background imagery will come into play whenever the threat of radiation arises, even if it is in very slightly contaminated recycled material which poses no actual health risk.

— *Trust*. We are more afraid when we don't trust the agencies or officials supposed to protect us, or the industries creating the risk. Do we trust their competence? Their honesty? Their motives? People inherently question the motives and honesty of business and industry, and the motives and honesty *and competence* of the politicians who run our governments. Indeed the historical record is rich with examples of incompetent performance, businesses and governments keeping secrets, or lying, in regards to many nuclear and radiological events.

4. RISK COMMUNICATION

These insights into how people perceive risk may seem discouraging. They seem to argue that people can’t help but be irrational about risks, that they can’t help but make judgments that are wrong, judgments which fly in the face of the facts. This is certainly the case with fear of nuclear radiation, where the fear in many cases far exceeds the actual physical risk.

In fact, however, this richer understanding of how people perceive risk is the first and most important step in communicating about those risks more effectively, in ways that understand and respect people’s perceptions, and in so doing, build trust, and therefore have more influence on people’s judgments. This is the discipline of risk communication, and it is an important tool for any business or agency addressing the problem of public concern about radiological contamination of recycled materials.

Work on risk communication began in the late 1970s with efforts by the nuclear and chemical industries in the USA to counteract widespread public concern about those technologies, where efforts to provide clear, understandable information was not enough. People were still afraid, so businesses and governments looked to social science for help in communicating about these risks more effectively. Unfortunately, many still believe that risk communication is just a matter of making information understandable. This is particularly true in fields run by people with scientific and engineering backgrounds, like nuclear technology.

For decades this 'just educate them about the facts' approach has failed, because it has not accounted for the perception of risk. Communication that offers the facts but fails to account for the affective side of our risk perceptions is simply incomplete.

Here, then, is a more complete definition of risk communication;

'Policies, messages, and other interactions that incorporate and ***respect*** *the perceptions of the information recipients, intended to help people make more informed decisions about threats to their health and safety.'*

This definition emphasizes that

— Risk communication is a matter of what an organization does, not just what it says. (For example, if a metals recycling plant installs monitors to detect radiological contamination when materials are delivered, that action sends a message that the company takes the issue seriously. That builds trust and influences public perceptions and fears).
— Risk communication must account for the psychological, emotional component in people's perceptions of risk. Issues of trust and control and risk versus benefit are as important, and often *more* important, than explanations of the sieverts and becquerels.
— Risk communication will be more effective if it is thought of as dialogue, not instruction. It will be more successful if the goal is to encourage certain behaviours, not simply to expect that the information recipients will think and do what the communicators want them to. Risk perception, in the end, is about nothing less important than survival. Making judgments about survival is not something most people will turn over to someone else. Any organization that implies that people should feel the way the organization thinks they should feel about a risk, and sends the message that essentially says 'you should feel the way we feel', will damage trust and have less effect, not more, with their policies and messages.

Here are a few basic suggestions for effective risk communication about radioactive contamination of recycled materials:

- — Openly acknowledge risks as well as discuss the benefits of recycling;
- — Establish mechanisms for continuous public input, or for answering questions from the public, to create a true dialogue;
- — In cases in which contamination occurs, give people a sense of control by telling them what they can do, e.g. shelter, evacuate, don't go anywhere, seek medical examination, take iodine pills;
- — Admit errors and take responsibility;
- — Honestly acknowledge uncertainty when it exists;
- — Avoid keeping secrets (though this is difficult in events involving security and law enforcement).

The issue of radioactive contamination of recycled materials is a risk management challenge. It has physical and procedural aspects to reduce the likelihood of contamination. It also has significant perception aspects, since the actual physical risk is low but the fear of the risk is high. An understanding of risk perception, and application of that understanding via better risk communication, should play a large role in the management of this challenge.

CONFERENCE SUMMARY AND CONCLUSIONS

Metal recycling has become an important industrial activity worldwide; it is seen as being socially and environmentally beneficial because it conserves natural ore resources and saves energy. Radioactive material may become associated with scrap metal inadvertently and if it is melted can cause health, economic and public acceptance problems for the metal industry.

The aim of this conference was to share experiences and, if possible, to contribute towards the resolution of the problems caused by the inadvertent presence of radioactive material in scrap metal.

This is an issue of wide concern; it involves regulators, industry and the public. The high level of interest in the subject is shown by the conference attendance of more than 200 participants from 62 countries and five international organizations.

The technical contributions in the form of oral presentations and posters from all around the world have revealed that the problems discussed at the conference are truly global in nature and demand an urgent solution. Altogether, 40 oral and 38 poster contributions from more than 60 countries and international organizations were presented.

The presentations included experiences from incidents involving radioactive material in scrap from 10 countries. They showed that the health effects resulting from such incidents can be significant but, in addition, that the consequences of radioactive material in scrap reaching the processed metal product can be costly. Such events have led to plant closures and to expensive cleanups. Even the discovery and recovery of radioactive material from scrap metal loads at entrance gates to scrap metal and metal processing facilities can be disturbing and costly. In addition, such incidents lead to a loss of trust in the recycled metal industry.

At the base of the problem are the deficiencies which still exist in the control of radiation sources and materials. Considerable efforts, both at national and international levels, have gone into securing sources and improving controls on them. Many countries have made commitments to resolve the problem by formally associating themselves with the international Code of Conduct on the Safety and Security of Radioactive Sealed Sources.

Increased monitoring at national borders, at entrances to scrapyards and steel plants has helped to improve the situation, but globally, the monitoring is incomplete in its coverage. Incidents continue to occur and reports at the conference have provided clear evidence of the incompleteness of the monitoring. In addition, there are limits to the effectiveness of detection methods.

Reducing the magnitude of the problem by prevention, detection and subsequent reaction requires the cooperative efforts of all concerned parties, that is, the scrap metal carriers, the scrap metal industry, the steel industry, the national regulators and the radioactive waste management organizations. An effective national model is that of Spain and its protocol, while international recommendations, aimed at the global situation, have been provided by the United Nations Economic Commission for Europe. The essential features of the recommendations are prevention, detection and response. National strategies based on these three guiding steps were repeated in many of the presentations at the conference.

The Spanish experience with its Protocol has shown the value of an all-inclusive approach in which the concerned parties are encouraged to feel that they are all part of the solution; a collaborative approach in which no-one is blamed and the emphasis is on finding a solution.

The presentations and posters displayed at the conference showed clearly that the problem is global and therefore requires a global reaction. Translating the positive national experience to the international scale will not be easy but the lessons learned from some national experiences are valid. The global situation can only be improved with collaborative efforts and improved trust between all major stakeholders.

From the presentations and discussions it is clear that many countries feel that the main problems come from imports from outside their frontiers. The problems are particularly difficult for small countries with limited experience and resources, especially those which have borders with several other states. At present, there are no international legal instruments that cover the trans-border issues associated with radioactive material found in scrap metal. Several examples of the trans-border issue were presented. For example, there is no international requirement to report a load which is rejected at a border to the authorities in the neighbouring countries and there is no international requirement for the certification of monitoring of loads being imported into or exported from a country.

It is also clear that countries have different acceptance criteria for radionuclides in metal scrap leading to possible acceptance problems at borders.

The participants of the conference were unanimous in recognising the potential benefit that would result from establishing some form of binding international agreement between governments to unify the approach to trans-border issues concerning metal scrap containing radioactive material. This should now be a subject for the international agencies to consider and to determine the most effective mechanism for the purpose. In doing this they might explore the possibility that certain existing international instruments, for example, the international Regulations for the Transport of Radioactive Materials, could address some of the trans-border issues.

Many of the topics raised by conference participants in this context have been addressed in the United Nations Economic Commission for Europe recommendations and they could, therefore, be one of the starting points for deliberations.

In many countries, the discovery of radioactive material in scrap is seen by persons in the scrap metal industry as a negative thing because it can bring difficulties with the authorities, a loss of production and a waste of time. This can cause such incidents to be hidden from the authorities. It was suggested that giving awards to persons for the discovery of radioactive material could transform the situation and lead to greater openness in reporting.

Although the majority of reported incidents involving radioactive material in scrap metal are concerned with naturally occurring radionuclides and orphan sources, the conference also addressed the issues surrounding the recycling of metals from the nuclear industry — which is practised on a limited scale at present but which may be expected to grow as more nuclear facilities are decommissioned in the coming years.

It was argued that the nuclear industry needs to recycle its metal — the disposal alternative may not always be available or be too expensive for the large volumes concerned and, in addition, it is wasteful of valuable metal resources. However, the potential presence of radioactive material in scrap metal from the nuclear industry has made the steel industry reluctant to accept scrap from this source.

The nuclear industry in several countries is using the clearance concept to determine which materials can be released from regulatory control for recycle. Most of the released metals have so far been used in controlled applications or returned for reuse within the nuclear industry. Generally, the release of cleared metals from the nuclear industry for unrestricted use has not yet gained acceptance. This is a key issue for the future and the determination of an agreement on appropriate acceptance criteria for radionuclides in metal scrap and processed metal would be one step towards its resolution.

In some countries, scrap metal from the nuclear industry is already accepted by the local steel industry. In these cases it has been recognized by the local steel company that the scrap is carefully controlled and of high quality. An important element in this context is the understanding and trust developed between the supplier and customer.

The issues surrounding inadvertent radioactive material appearing in scrap metal and processed metal may cause public alarm and concern. Therefore, in all matters related to the problem the views of the public must be considered. The industries and the national authorities should try to obtain the trust of the public by being open and transparent in what they do, by providing proper information and by communicating effectively. It is essential that the public is assured that the authorities are making all possible efforts to ensure its protection and wellbeing.

Clearly, there are many issues for the nuclear and steel industries to resolve. Currently there are too few occasions at which the representatives of the nuclear and steel industries can meet to discuss their problems. A way forward might be to create a forum where this could occur. It might help to improve understanding of the issues and concerns of both sides and to build mutual trust.

In summary, the conference achieved the objectives set for it — by successfully promoting the exchange of information between those concerned with the problems of inadvertent radioactive material in scrap metal. In addition, it has indicated a way forward to help resolve some of the major issues raised through the development of an international agreement between countries on the subject.

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Radioactive material may become inadvertently associated with scrap metal and, when melted, can cause ill health effects as well as economic and public acceptance problems for the metal industry. This issue has come to the forefront in recent years and concerns have been voiced by the metal recycling and production industries. Action to prevent the occurrence of such events has been taken in many countries exerting greater control over radioactive sources.

This conference made it possible to share experiences and, when possible, to contribute towards the resolution of the problems caused by the inadvertent presence of radioactive material in scrap metal.

These proceedings include: the opening speech, papers presented orally, summaries of the five plenary sessions and the conclusions of the conference.

A CD-ROM, which is attached to the back of this publication, contains the PowerPoint presentations.

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