IAEA-TECDOC-1484

Regulatory and management approaches for the control of environmental residues containing naturally occurring radioactive material (NORM)

Proceedings of a technical meeting held in Vienna, 6–10 December 2004

IAEA
International Atomic Energy Agency

January 2006

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized 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.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (i.e. all these areas of safety). The publication categories in the series are **Safety Fundamentals, Safety Requirements** and **Safety Guides**.

Safety standards are coded according to their coverage: nuclear safety (NS), radiation safety (RS), transport safety (TS), waste safety (WS) and general safety (GS).

Information on the IAEA's safety standards programme is available at the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at P.O. Box 100, A-1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by e-mail to Official.Mail@iaea.org.

OTHER SAFETY RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety and protection in nuclear activities are issued in other publications series, in particular the **Safety Reports Series**. Safety Reports provide practical examples and detailed methods that can be used in support of the safety standards. Other IAEA series of safety related publications are the **Provision for the Application of Safety Standards Series**, the **Radiological Assessment Reports Series** and the International Nuclear Safety Group's **INSAG Series**. The IAEA also issues reports on radiological accidents and other special publications.

Safety related publications are also issued in the **Technical Reports Series**, the **IAEA-TECDOC Series**, the **Training Course Series** and the **IAEA Services Series**, and as **Practical Radiation Safety Manuals** and **Practical Radiation Technical Manuals**. Security related publications are issued in the **IAEA Nuclear Security Series**.

IAEA-TECDOC-1484

Regulatory and management approaches for the control of environmental residues containing naturally occurring radioactive material (NORM)

Proceedings of a technical meeting held in Vienna, 6–10 December 2004

IAEA
International Atomic Energy Agency

January 2006

The originating Section of this publication in the IAEA was:

Waste Safety Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

REGULATORY AND MANAGEMENT APPROACHES FOR THE CONTROL OF ENVIRONMENTAL RESIDUES CONTAINING NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)
IAEA, VIENNA, 2006
IAEA-TECDOC-1484
ISBN 92–0–113305–7
ISSN 1011–4289

Printed by the IAEA in Austria
January 2006

FOREWORD

Radionuclides of natural origin are present throughout the environment in which we live. Some of these, such as those contained in the ores of uranium and thorium, have been exploited commercially for a long time and the management of the waste arising from such exploitation and the associated radiological safety issues have been well documented and are readily understood. However, whilst the existence of many other natural sources of radiation has been known for many years, it is only in relatively recent times that the community has come to consider if the presence of such naturally occurring radioactive material (NORM) in products and waste associated with everyday life is an issue that should be examined in more detail, especially from a safety viewpoint. In particular, as technology changes there are many new materials being developed by different methods and the processing of natural materials such as ores and soils is increasing. Also as technology develops so the waste streams from established industries may be causing new problems as they may be concentrating NORM in their waste to levels that are now exceeding the point at which regulatory concerns may be raised.

The management of such waste containing NORM has been a growing focus of activity for the radiological protection community in recent years. There are a number of issues to be considered, not least of which is that many of the industries involved in producing waste containing NORM are, for the most part, not normally associated with radioactive material and the associated radiological protection requirements. Another point is that much of the waste containing NORM is produced in large volumes although the activity concentration may be low. These characteristics present their own particular management problems, especially if the waste contains sufficient radioactive material such that it cannot be released for reuse, recycling or free discharge as a disposal option.

The IAEA has been implementing a number of actions in relation to the issues of management and regulation of NORM and waste containing NORM. As part of this campaign, technical meetings were held in Vienna in 2002 and 2004 as part of the process to develop guidance for Member States on this topic. This TECDOC contains presentations made at both meetings as well as the record of the ensuing discussions and working group outcomes from the 2004 meeting. The outcomes of the meeting form one contribution to the development of an IAEA Safety Guide on the Management of Waste containing NORM.

The IAEA wishes to express its gratitude to all those who participated in the technical meetings and assisted in the drafting and review. The IAEA officer responsible for the preparation of this report was P. Waggitt of the Division of Radiation, Transport and Waste Safety.

CONTENTS

SUMMARY 1

PAPERS PRESENTED AT THE TECHNICAL MEETING, 6–10 DECEMBER 2004

Overview of NORM situation in Brazil: Technical and regulatory aspects
H. Fernandes, M. Pires Do Rio, M. Franklin 17
Regulation and management of NORM residues in Bulgaria – current status and challenges
C. Necheva 29
Studies on NORMs in Cuba: Results and perspective
J. Tomás Zerquera, M. Prendes Alonso, O. Ramos Biltres, J. Rodolfo Quevedo 33
Control of residues containing naturally occurring radioactive material in Germany
K. Gehrcke, J. Gerler, E. Ettenhuber 41
Managment and regulation of residues containing NORM in Greece
V. Koukouliou 49
Regulatory and management approaches to NORM residues in Malaysia
M. Omar, I.L. Teng 55
Regulatory approaches for NORM residues in the Netherlands
J. Van Der Steen 61
Regulatory and management approach for TENORM in Nigeria
I. Isa Funtua 75
Regulatory and management approaches for the control of environmental residue containing naturally occurring radioactive material, a South African experience
S.A. Tsela, Z. Zituta 79
Proposal of the Swedish Committee on Management of Non-Nuclear Radioactive Waste (IKA) and the implications for the management and storage of TENORM and NORM waste
J-C. Lindhé, L. Mjönes, N. Hagberg, A-L. Söderman, G. Åkerblom 89
TENORM regulation in the United States of America
L.W. Setlow 103

ANNEX I: PAPERS PRESENTED AT THE TECHNICAL MEETING, 23–27 SEPTEMBER 2002

UK regulations for NORM
R. Smith 113

Problems in regulation of safety during management of waste containing naturally occurring radioactive material (NORM)
M.V. Mihajlov, S.A. Sitnikovz 117

LIST OF PARTICIPANTS 121

SUMMARY

1. INTRODUCTION

1.1. Background

Radionuclides of natural origin are present in most material, the most common being the radionuclides of the uranium and thorium series and potassium-40. This material is commonly referred to as Naturally Occurring Radioactive Material (NORM). In some materials activity concentrations of radionuclides of natural origin are significantly elevated, to the extent that regulatory control may be required for radiation protection purposes.

Regulation of NORM presents a range of new challenges for both regulators and operators. Unlike more traditional industries dealing with radionuclides, NORM industries have generally had little, if any, radiological oversight and may not be equipped for radiological monitoring. Some consumer goods containing NORM that have not traditionally been considered as a radiological problem (such as some fertilizers) may need to be considered for regulation and this may have social and economic consequences. The transport and disposal of NORM are also a concern that may need to be considered, particularly due to the large volumes. For the majority of NORM, disposal has been by conventional means in the same way as for non-hazardous waste, with no specific attention to radiological aspects. In some cases, there may be a need for intervention into existing NORM disposal sites.

The International Commission on Radiological Protection (ICRP) published ICRP No. 82 [1], *Protection of the Public in Situations of Prolonged Radiation Exposure* in 2000. This document provides guidance on managing residues that have the potential to impact on the radiation exposure of the public, such as those arising from NORM based industries. However, NORM-containing residues may have been the result of any of three different situations: residual waste created as the result of a past practice[1] or activity; residual waste created by an ongoing practice; and waste which will arise from future practices. Regulation of NORM may therefore be consistent with consideration of a practice, an intervention[2] or a combination of both. Widely differing regulatory approaches are used internationally and a review of the regulation of NORM is timely.

In 1999 the IAEA published a Safety Guide on Occupational Radiation Protection, jointly sponsored by the IAEA and the International Labour Office, [2] which gave specific guidance on the application of the Basic Safety Standards [3] to occupational exposure to natural sources of radiation. An assessment of occupational protection conditions in workplaces with high levels of exposure to natural radiation was made at an IAEA Technical Meeting held in 2001 and referred to at a further IAEA Technical Meeting held in Vienna in 2002 to discuss issues of NORM waste management.

---

[1] Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or likelihood of exposure of people or the number of people exposed. IAEA Basic Safety Standards [3].

[2] Any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident. IAEA Basic Safety Standards [3].

Since the meeting in 2002 there have been further Agency documents published that have a bearing on the issues of management and regulation of residues containing NORM.

These include the following Safety Standards:

- WS-R-3: Remediation of Areas Contaminated by Past Activities and Accidents [4];
- RS-G-1.6: Occupational Protection in the Mining and Processing of Raw Materials [5];
- RS-G-1.7: Applications of the Concepts of Exclusion, Exemption and Clearance [6];
- WS-G-1.2: Management of Radioactive Waste from the Mining and Milling of Ores [7].

A number of Safety and Technical Reports pertinent to the issues have also been published, including:

- Safety Report No. 34: Radiation Protection and the Management of Radioactive Waste in the Oil and Gas Industry [8];
- Technical Report No. 419: Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation [9].

Thus NORM issues in relation to worker protection and waste management have been addressed to a degree, and work in progress will continue to address worker safety and waste management issues in more industries. However, the issues of public and environmental protection remain an area where guidance is still needed.

The findings of the December 2004 meeting will contribute to a work plan for future activities in the area of environmental protection. However, there is a range of radiation protection issues, arising from the mining, processing, utilization and disposal of NORM that have not yet been covered in IAEA safety documents. These include guidance for the regulation and management of residues containing NORM with the aim of improving protection of the public and the environment from any adverse impacts. Thus there is a need for a Safety Guide to address the Safe Management of Wastes containing Naturally Occurring Radioactive Material (NORM).

1.2. Objectives of the meeting

The objectives of the technical meeting that was held by the IAEA on 6–10 December 2004 were:

- To promote information exchange on approaches being used by Member States to regulate and manage NORM residues;
- To explore possible common approaches to regulation;
- To examine real and potential impacts on industries.

1.3. Scope of meeting

The technical meeting covered the regulation of NORM and NORM industries in Member States with particular emphasis on potential public exposure to, and the residues arising from, these activities, and on aspects of how NORM differs from material containing radionuclides of artificial origin. The meeting examined the impact of NORM residues from past industrial practices and activities, current practices that are generating NORM residues and potential future practices processing NORM. Issues relating to the mining and processing of uranium and thorium ores, the management of waste generated by such activities and occupational protection for mining and processing of raw material were not the focus of this meeting, though they were considered during the meeting deliberations.

1.3.1. Participation

Initially the technical meeting was directed toward persons from regulatory bodies and their technical experts responsible for the regulation of NORM. However, Member States were advised that other government organizations or industry representatives with a major interest in NORM might find attendance at the meeting beneficial. The meeting was thus directed at a broad spectrum of professional disciplines, including radiation protection, environmental engineering, radioactive waste management and radiological assessment.

1.4. Agenda of the meeting

- Opening of meeting
- Opening by Mr. Abel J. Gonzalez, Director, Division of Radiation, Transport and Waste Safety-NSRW
- Statement by Chairperson, Mr. Loren Setlow, USEPA
- Presentations by interested parties
- Work groups on primary issues
- Recommendations and action plan development
- Closure of meeting

2. THE MEETING

Following welcoming remarks by IAEA officials and staff, representatives of Member States gave prepared presentations on:

1. National approaches to the regulation of NORM residues in past, present and future practices;
2. Identification of the primary issues relating to the regulation of NORM residues.

In view of the relevance of the previous meeting held in 2002, delegates were provided with some notes and papers that had been presented at that meeting, together with the papers from the presentations made at this meeting. Two papers from the 2002 meeting have been included with the present meeting's papers in this report (Annex I).

2.1. Discussion of presentations

The prepared presentations given during the first and second days of the meeting provided attendees with an opportunity to better understand:

- The diversity of approaches taken in relation to NORM management in the Member States represented by the meeting attendees;
- The diversity of NORM wastes and products which were being managed;
- The extent to which national regulations or standards had been developed for management of those materials;
- Relevant policies, both national and international, which affected the development of the regulations and standards;
- The possible impacts of those regulations on affected industries.

Several important concepts and issues of concern for the regulation of NORM waste and products were discussed. The results of an earlier U.S. National Academy of Sciences study [10] had found that differences in national and international NORM regulations and standards were the result of differences in risk management policy rather than differences in underlying scientific information. The study also noted the radiation effects of NORM on humans and the environment were no different from that of any other type of radiation, but differences among the different NORM chemical and physical characteristics required separate analyses for risk and dose management. The study also noted the unique problem of distinguishing and accounting for background radiation from the same radionuclides present in the NORM material. It was apparent from the discussions that NORM is generated by a wide variety of resource extraction, manufacturing and water processing industries, many not usually associated with radiation protection requirements, and that the list of affected industries continues to grow. The impact is that more members of the public are exposed to radiation from NORM waste and products than from any other class of radioactive material. The introduction of regulation to industries previously considered to be 'safe and non-radioactive' will undoubtedly provoke reaction and generate concern amongst members of the public. In fact, one of the most widely reported radiation problems came from residential reuse of areas contaminated with NORM. There were also discussions about the problems that have arisen, or may arise, from the use of NORM contaminated waste products as building material and the recycling of NORM waste or NORM bearing material into consumer products.

Reported waste disposal methods and approval processes for disposal and storage sites varied widely, for specific industries and the types and state of the waste (sludge, scales, liquids, dusts). The methods for taking into account the radon risk from residual NORM and national decisions on appropriate means for NORM waste management were also discussed. It was noted that statutory and regulatory controls also varied widely with some nations having complete schemes of NORM radiation protection and waste management, and other nations having no separate scheme whatsoever. A common issue was the differing national approaches as to what constituted NORM, and consequently, which industries, residues and products are currently covered by relevant guides and regulations. In some presentations, a concern was expressed in relation to what could be done to assist industries in managing the risks and also to assist some countries in easing the burdens of regulation to keep their products that contain NORM competitive in the world market.

Following the prepared presentations, a short overview of ongoing activities in the IAEA on NORM related projects was provided to assist the meeting attendees in framing and directing their efforts over the following days. The IAEA presentation made reference to efforts being made by the IAEA to provide further information and guidance on occupational exposures associated with the NORM industry.

2.2. Topics for and actions of working groups

Discussions following the presentations allowed attendees from countries not providing written presentations to contribute their views on the most pressing concerns regarding NORM, and permitted all attendees to identify the most important issues that should be examined during the meeting.

Based on these discussions, it was determined that the following were the most common issues of concern:

- Waste and product safety and management;
- Practical solutions;
- Regulatory issues;
- Public perception.

The attendees made a decision to create two separate working groups. The first group examined regulatory issues, especially conflicts and inconsistencies, and options for managing public perception. The second group focused on waste and product safety and management issues and on finding practical solutions for the resolution of these issues.

The working groups met over a two and a half day period. Each day commenced with a short plenary session to allow groups to describe and discuss progress. On the last day of the meeting, there was a final session to report on the recommendations of each group. This led into a discussion session to determine a consensus on the working group reports. Once this had been achieved the meeting was closed.

3. DISCUSSION

3.1. Working Group 1: Regulatory Issues and Public Perception

3.1.1. Discussion points

All the Member State representatives agreed management and regulation of residues containing NORM to be an important issue, from both radiological and public perception perspectives.

Various countries have different rationales for regulation implementation, some based on activity concentration levels, while others are based on dose levels. Some countries base their regulatory processes on both rationales.

Some European countries have well established regulatory systems with reference levels for NORM or NORM bearing material or residue as well as criteria for clearance and exemption.

In the USA, regulatory systems have either reference levels for NORM or radiation sources in general, though clearance and exemption criteria are currently being evaluated.

From the discussions it appeared that some of the adopted reference levels are not easily transferable to other Member States and could result in socio-economical difficulties. These difficulties could arise as some material, classified as a residue in one Member State, may be considered as product in another state and could only be transported as radioactive material. Such requirements could lead to an increase in costs, which in turn could render operations no longer economically viable. This might result in cessation of commercial activity, which in turn would cause economic hardship and subsequent social problems.

However, not all the Member States have carried out extensive surveys to characterize the residues in terms of their radiological characteristics. Accordingly, doses incurred by members of the public and workers, and any associated environmental impacts due to NORM residues and work activities, may not be fully understood.

Management practices that are accepted in some Member States are not necessarily encouraged in others. An example is the methods of disposal of resulting waste material. Some legal options for NORM residue disposal might include the release and dilution of residues into water bodies, incorporation back into the natural environment or underground placement. However, in some Member States one or more of these options may not be legally acceptable. The same situation may exist when considering possible recycling and reuse of material. For example, the recycling of residues containing NORM for use in road construction is permitted in some Member States but not in others. Not all NORM containing residues are major issues of concern in some Member States.

The relationship between representatives from regulatory bodies and industries, with respect to legal requirements, is similarly not uniform. However, the participants at the meeting believe, in general, that industries accept regulation, especially when their public image may be damaged by not adopting the regulations. It seems that for industries with more economic resources, it is easier to comply with the regulations that are being put in place (even though they may not consider them justified) than to risk possible adverse publicity and loss of reputation. But this situation can be dramatically different for smaller industries, especially those from developing Member States.

It was also agreed by the group that prevailing radiation safety principles like exclusion, clearance, exemption and intervention may be applied with respect to NORM. However, the degree to which these principles should be applied is dependent upon the national regulatory framework.

It was also observed that some industries in different countries might not even be aware of the problem or the potential for their involvement in new regulatory regimes. As a consequence, they are likely to be caught by surprise should new regulations be introduced and enforced.

Another issue discussed was a need for a more detailed examination of industrial operational processes. Such a study could result in better identification of the process steps in which enhancement of radiation levels in material is taking place, especially in residues. This would help to improve management of the residues, and might offer opportunities to modify the stage of the process whenever this could be applicable or justified. This is already being addressed in the IAEA's work programme, through the development of reports on specific industrial processes

3.1.2. Relevant issues

It was observed that some Member States do not have a complete suite of regulatory processes to deal with radiation protection issues. As a result the necessary institutional infrastructure to put in place national programmes to deal with NORM residues may not exist. In such cases relevant regulatory agencies may differ from country to country (Bureau of Health, Department of Environmental Protection, etc.). Some of the basic information required to assess the national situation in a Member State, such as a national inventory of legacy sites and locations with on-going work activities involving NORM, may also not exist.

Important aspects like exposure scenario development and modelling were not discussed in depth and may represent important themes for further technical meetings. Use of these exposure scenarios would be an important tool for countries with less experience in this kind of assessment task.

It was recognized that the judicial system (legal representatives) plays an important role in decisions concerning NORM industries (contaminated areas). This may be a key factor in the implementation of some of the decisions made by local authorities.

3.1.3. Public perception

The public is made up of individual citizens, company employees, non-government organizations, industrial associations and governmental agencies. Each of these may have a very different understanding of radiation and risk concepts, and little or no understanding about NORM.

Levels of trust regarding environmental and radiation information are generally low for governmental and mass media organizations.

Public perceptions about radiation derived from natural sources, including radon, versus radiation from artificial radionuclides may be different. There is a general lack of understanding that radiation from both sources has the same biological effect.

3.1.4. Conclusions of Working Group 1

Having agreed upon the above points, the group then reviewed their ideas and came to the following conclusions:

- Industries whose processes generate NORM-containing residues should perhaps not be considered practices.

- A dose criterion that lies between the established limits for a practice (10 μSv/a) and an intervention of 0.3 mSv/a effective dose (including all sources and all exposure pathways) over the background might be considered as a reference value on which decisions could be based to determine whether residues or processes require regulation or not. It could allow for harmonization with the prevailing standards applicable to nuclear industries. It was also suggested that, in terms of public perception, it would be very difficult to legislate different values from those already in use. However, this reference value level would not have to be seen as a limit. Variations above and below this value are to be accepted as appropriate, and the optimization principle would need to be applied, with steps taken to ensure the adequate involvement of the public in the decision making process.

- Reference levels could be expressed in terms of activity concentration, but based on dose criteria. However, background levels of naturally occurring radionuclides would have to be taken into account when establishing reference levels.

The group reached a preliminary consensus that this value should not cause any undue economic restriction to most of the industries identified by the group as having potential to be involved in, or subject to regulation of, this issue.

Three different stages in industry ‘life-cycles’ were identified and assessed:

(a) Pre-operation: Potential NORM related problems need to be considered during the planning phase of a specific work activity.

(b) Industries already in operation: Two situations can be found in this stage:

  - Existence of residues still at the property of the industry and still subjected to some form of control; and/or
  - Releases of effluents (liquid and gaseous) into the environment.

In both cases the industry needs to put in place strategies to reduce the overall potential exposure to the public to levels acceptable to regulators.

(c) Post-operation: Operations that have resulted in the development of contaminated areas resulting from such activities as mining and associated minerals processing (tailings, waste rock, etc.), phosphate production, processing of minerals and oil and gas extraction (scales, contamination of soils by formation water, etc.) are considered an intervention-type situation. Countermeasures, which may include remediation, need to be justified and optimized. Even though a Member State may have exempted a residue containing NORM from regulation, its natural radioactivity may still be controlled by national or international transport regulations.

3.2. Working Group 2: Waste and Product Safety and Management; Practical Solutions

3.2.1. Discussion points

The residues of concern containing NORM are derived from work activities and/or processes that are generally processing large volumes of material containing radionuclides of natural origin. These processes generate either large amounts of residue containing very low levels and concentrations of radioactivity, or small quantities of residues containing relatively high concentrations of radioactivity. It is also possible that associated processes at the same site could be producing both classes of NORM.

NORM residues (which may comprise waste material[3] and/or products depending on the situation) generally require different approaches for safe management from those used with radionuclides of artificial origin. These NORM-containing materials may be described or defined, particularly in national legislation. NORM-containing products may be either material that could be recycled for another use (e.g. coal ash or scrap metal), or they may be

[3] Waste is defined by IAEA as material for which no further use is foreseen.

considered raw materials used to create consumer or industrial products (e.g. zircon sand used to glaze ceramics, or titanium sands processed to make paint pigments).

A table which appears as Table II in Technical Reports Series No. 419 [9] gives an overview of the sources of NORM-containing materials and residues, existing disposal options and a review of the technologies that may be employed in some circumstances to condition and manage the residues. The present working group assessed practical solutions for the safety and management of NORM-containing residues, including waste and products.

3.2.2. Issues

The regulatory decisions as to what may be appropriate disposal options for NORM-containing residues differ from country to country. There may also be differences between local and national policies and strategies on such issues. The characteristics of the NORM-containing residues have been described previously.

Management options depend on both technical and non-technical factors. Technical factors include the suitability of land used in disposal programmes for residues containing NORM, the availability of land, the varieties of technology available to manage NORM waste, climate, geology, water, disposal location, environment, the volume of the material, the physical state of the material, and rate of production of the material now and into the future. The non-technical issues include national policies and legal framework, socio-economic aspects, resources for implementation and management (human, technical and financial), cultural aspects and the public perception of risk about reuse of material and efficacy of the proposed disposal facilities.

A further issue is the matter of reuse options for NORM residue. Many of the NORM residues being considered here have some potential for use in other processes to become new products. Some examples are provided in Table I below.

TABLE I RESIDUE TYPES – REUSE OPTIONS

Waste material/Residues	Products and/or reuse options
Waste, $T^{1/2}$ > 30y	
Small amounts of metals with high activity concentration.	Metal recycling
Large volumes with low activity concentration:	
Phosphogypsum	Water purification Building materials Fertilizer Soil improvement (agriculture) Daily cover for landfills
Fly ash Bottom ash	Road construction Cement industry Fertilizer & soil conditioner Inclusion in cinder or concrete building blocks, or concrete

Waste material/Residues	Products and/or reuse options
Waste, $T^{1/2} > 30y$	
Slag	Road construction
Plastic	
Rubber	
Decommissioned construction materials (concrete, soil, bricks, etc.)	Gravel
Technology related (scales, sludge)	
Liquid waste	Reuse, closed-circuit process
Waste rock heaps	Cover material for tailing ponds
Mineralized waste rock heaps	Processing metal extraction
Tailings ponds	Underground backfill
Filter masses from water treatment	
Zinc-rich filter cake	
Solid residues from titanium oxide production	Backfill into remediated sites

Table 1 is only a partial listing. More data may be found in individual country presentations from this technical meeting, set out after this summary, and in Ref. [9]. Whenever NORM residues are being considered for reuse or recycling, the nature and concentration of the radionuclides present, the amount of material, public safety and environmental protection are all factors that have to be taken into consideration.

3.2.2.1. Historical waste (legacy waste)

Existing amounts of NORM containing waste arising from previous industrial activities (now ceased) may be found in many countries. Very often this waste is stored within the boundaries of the premises of their origin. Other material might be considered to have been cleared or exempted from regulation and so are allowed to be released into the environment. Unsecured waste presents potential health, safety and environmental risks. As a result, the safe management of NORM-containing waste needs to be assured including relevant monitoring (for example, radiological parameters, chemical parameters, physical state and stability). The responsible organization for the safe management of such waste needs to be clearly addressed in national strategies.

3.2.2.2. Disposal options presented by Member States

A wide variety of methods for NORM disposal was identified at the meeting and these are listed below. Not all of these methodologies are acceptable to each Member State, nor are they all necessarily available to each Member State. Additional methodologies have been described in Ref. [9]:

— Landfill (stacks, disposal at site, authorized NORM landfills);

— Underground facility;

— Disposal in regional or national repositories;

— Well injection;

— Abandoned mines;

— Land spreading and incorporation;

— Storage in lagoons or evaporation ponds;

— Sanitary sewer system (for drinking water treatment waste only);

— Uranium mill tailings impoundments or other tailings storage facilities.

3.3. Conclusions of Working Group 2

There have been measurements made of radiation levels in individual consumer products. However, there has not been any major effort made to evaluate the accumulated dose to a member of the public as a consequence of exposure to such materials.

For the most part these products are generally considered to contain radioactivity at a level below that at which control is required. Alternatively the material may be considered to be suitable for exclusion from regulation due to the concentrations of the individual radionuclides. The majority of such materials are not licensed. In many cases the producing companies are not aware that their products contain radionuclides of natural origin.

Many building products contain NORM and in many countries there has been no effort made to measure radioactivity in such materials. Radon emanation has generally not been taken into consideration. Some states already have strict regulations on building materials. The recycling of NORM containing residues such as phosphogypsum, coal ash and fly ash, and metals can also provide a radiation dose to building occupants. Mine waste and use of historical waste for house constructions may be among the most hazardous sources of NORM exposure.

In many industries, producing NORM-containing material or undertaking water processing may lead to an accumulation of radionuclides in or on metal components and this may cause problems for the reuse or recycling of such components and associated scrap metal.

4. FINDINGS

4.1. Findings of Working Group 1

- A common strategy/methodology would help Member States to identify the relevant NORM industries (work activities) that may be associated with potential radiological impacts;

- Training courses would help both regulatory bodies and industries to identify and implement effective ways of detecting and controlling potential exposure situations. In addition, material on dose modeling and scenario building for NORM exposure situations involving workers, members of the public and the environment would be useful in this regard;

- Guidance is lacking on how to deal with inconsistencies in classification and transport of NORM residues that have been released from regulatory control;

- There is currently no system of best practices for residue management;

- There is currently a lack of educational or guidance documents that can be used by Member States when informing the public of the risks associated with NORM residues. It would be appropriate for such material to take into consideration the different members of the public that need to be informed, the means by which the information is to be disseminated and the organizations which need to be involved in this process. Targeting of information at both the national and local levels would help to meet the differing needs of these two constituencies.

Findings of Working Group 2

- A review of the completeness and application of existing and draft guidance with respect to the management of NORM residues, including legacy waste, materials being generated by current ongoing operations and products would help determine if guidance coverage is incomplete for certain NORM-producing or utilizing industries, wastes and products.

- Current guidance and recommendations on geological and other repositories may provide advice and/or standards that are directly applicable to the safe management of NORM.

- A full environmental assessment of the practicality of the proposed disposal site for NORM disposal has not yet been carried out.

4.2. Findings of the meeting

A review and subsequent compilation of information on the accumulated doses from a variety of products and building materials containing NORM would help determine whether control of such products might be needed.

Clarity is lacking on whether existing documentation can provide explicit guidance on preventing the use of legacy mine tailings and other residues containing NORM as building materials. There is also a lack of international guidance on the prevention of construction of dwellings on sites that are contaminated with NORM or have NORM-containing wastes contained therein. These materials can generate relatively large radiation doses to a member of the public living in such a dwelling.

The cumulative dose arising from the use of NORM-containing material as fertilizers and soil amendments for growing food crops and forage for livestock has not been fully assessed.

Public information on these issues has not been adequately promoted.

There would be benefit in encouraging industries affected by NORM to use the best available techniques for reducing the amount and the NORM concentration of the produced residues. The material set out in Ref. [9] can provide useful information for Member States.

REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection of the Public in Situations of Prolonged Radiation Exposure, ICRP Publication 82, Pergammon Press, Oxford and New York (1999)

[2] INTERNATIONAL ATOMIC ENERGY AGENCY & INTERNATIONAL LABOUR ORGANISATION, Occupational Radiation Protection Safety Guide IAEA Safety Standards Series No. RS-G-1.1, IAEA, Vienna (1999).

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

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Remediation of Areas Contaminated by Past Activities and Accidents Safety Requirements, IAEA Safety Standards Series No. WS-R-3, IAEA, Vienna (2003).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Occupational Radiation Protection in the Mining and Processing of Raw Materials Safety Guide, IAEA Safety Standards Series No. RS-G-1.6, IAEA, Vienna (2004).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Concepts of Exclusion, Exemption and Clearance Safety Guide, IAEA Safety Standards Series No. RS-G-1.7, IAEA, Vienna (2004).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Management of Radioactive Waste from the Mining and Milling of Ores Safety Guide, IAEA Safety Standards Series No. WS-G-1.2, IAEA, Vienna (2002).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and the Management of Radioactive Waste in the Oil and Gas Industry, IAEA Safety Reports Series No. 34, IAEA, Vienna (2003).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation, IAEA Technical Reports Series No. 419, IAEA, Vienna (2003).

[10] NATIONAL ACADEMY OF SCIENCES, Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials, National Academy Press, Washington (1999).

PAPERS PRESENTED AT THE TECHNICAL MEETING IN VIENNA

OVERVIEW OF NORM SITUATION IN BRAZIL: TECHNICAL AND REGULATORY ASPECTS

H. FERNANDES, M. PIRES DO RIO, M. FRANKLIN
Instituto de Radioproteção e Dosimetria (IRD),
Comissão Nacional de Energia Nuclear (CNEN),
Rio de Janiero, Brazil

Abstract

The paper provides an overview of the current situation in respect of regulatory actions and technical developments in relation to NORM in Brazil. The discussion covers a number of exposure situations that have been evaluated and provides a background to the ongoing development of radiation safety regulations in Brazil. The paper also discusses the need for international harmonization of the approach to managing NORM.

1. INTRODUCTION

Over the last years, exposures to enhanced levels of natural radiation have become a matter of attention in the field of radiation protection. In this respect, several types of exposure situations or radiation sources have to be taken into consideration:

- Exposure to cosmic radiation during air flights, especially occupational exposure in aircraft;
- Exposure of the public to radon in dwellings;
- Underground and above ground work activities where high occupational exposures to radon progeny may occur;
- Work activities in which materials containing enhanced levels of naturally occurring radioactive materials (NORM) are handled or where such material results from processing less active precursors, possibly leading to significant exposures to the public and occupational exposures;
- Residues from former mining and milling and other industrial activities resulting in enhanced levels of exposure of the public to natural radionuclides.

From the point of view of the radiation protection principles, some of the above mentioned activities may be classified as being practices; others as intervention situations. In some cases, the distinction between these two categories is difficult.

It is clear that some of the exposure arising from natural enhanced levels of radiation can be of concern. However, in trying to provide adequate protection in these situations, one may argue if consistency with the current system of protection against exposure to artificial sources can be achieved. One has to take into account that most of the exposure situations already exist, and that the relevant industries are often highly competitive. One has also to consider the costs involved in providing enhanced levels of safety against exposures to NORM materials in on-going activities. It is clear that a pragmatic and flexible approach is necessarily to be based on the existing risk perception rather than consistently on an apparent equality of the objective risks [1]. The first aim should be reducing the highest individual exposures that have, until now, been left outside radiation protection systems; meanwhile, with the growing experience in managing radiation protection, pursuing a convergence in both systems.

2. KEY ELEMENTS

Some questions shall also be addressed in trying to develop a regulatory framework to deal with exposures to NORM. They are:

- Are NORM residues a major public radiological hazard?
- Are doses from NORM potentially far higher than doses from nuclear industries?
- Are NORM generating industries aware of the potential radiological problems associated with their processes?
- How should acceptance/refusal criteria and cross boundary issues be dealt with?
- Is all NORM waste equal?
- Is it an intervention or a practice?
- Should NORM be handled differently than other radiation source?

Over the last decade of the 20th century, a de facto international radiation safety regime has emerged [2]. This regime leads to a globally agreed international radiation safety consensus and hence to legally binding international undertakings amongst States, encompassing obligations relating to radiation safety. If that is the case, one has to keep in mind the fundamentals of radiation safety.

The very first issue to be considered is that exposures to NORM materials are mainly connected with low level radiation exposure. As such, any agreement on how to regulate low level radiation exposure requires a common understanding on the expected health effects of this type of exposure. Health effects that can be clinically attributable to radiation in the exposed individual (the deterministic effects) do not occur as a result of low level radiation exposure, as the dose threshold level above which these effects become manifest is much higher. Health effects that can be detected and attributed to radiation only through epidemiological studies of large exposed populations (the stochastic effects) are presumed to occur in direct proportion to the dose received, without a dose threshold. This approach has been confusedly termed the 'linear non-threshold' (LNT) hypothesis. Accordingly to the LNT has been inappropriately presented to regulators as a hypothesis requiring them to consider that at any level of dose, however small, a deleterious health effect [may] occur(s). However, the prevailing IAEA radiation standards [3] takes into account that:

> Everyone on earth is subjected to an unavoidable exposure to natural background radiation. The levels of the consequent annual dose are low but not negligible. As a minimum they are around 1 mSv, with the global average estimated by UNSCEAR to be 2.4 mSv. Millions of people around the world are exposed to typical elevated levels around 10 mSv and many thousands of people to higher levels of 100 mSv and above.

Above the prevalent background level, an increment in dose will result in a proportional increment in the probability of incurring a stochastic effect according to Fig. 1.

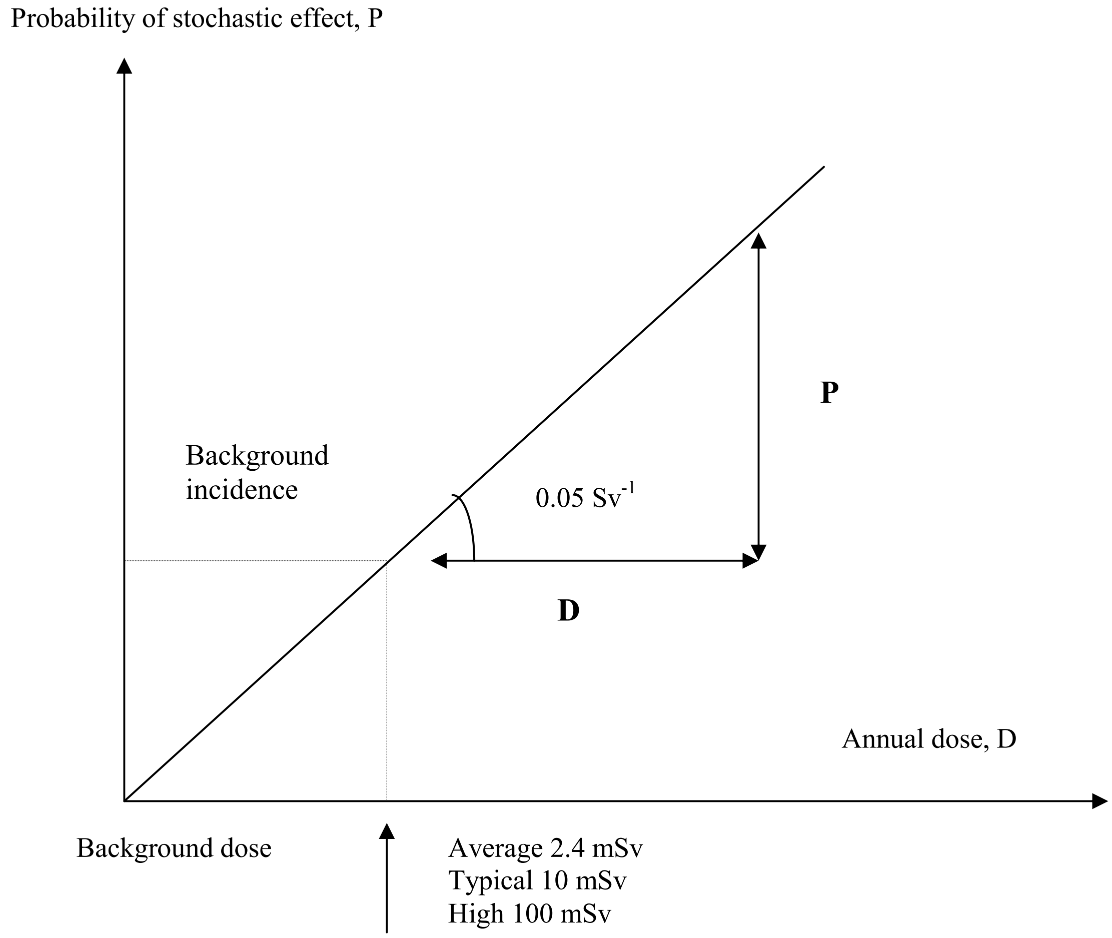

FIG. 1. Relationship between probability of stochastic effects and annual dose.

The controversy on LNT has focused on the biological effects of low doses of ionizing radiations; however, the bottom line issues in the debate are in fact how to regulate low level radiation and whether regulators need the assistance of a threshold dose. This theory is to be presumably provided by radiobiologists and radio-epidemiologists. The international standards presume that regulators should be able to regulate radiation sources properly with the current non-threshold linear dose response approach, i.e. with the approach that there is a linear dose-response, which is not necessarily linear at very low doses down to zero dose but which is linear above the comparatively higher background doses that all people unavoidably incur. It is important to note that the central issue here is the risks due to incremental increases in dose above background, not the risks due to the incremental increases themselves.

Of importance to the NORM situation is the division that the international standards provide between:

- ***Prospective situations*,** where protection can be planned in advance, i.e. a priori and prospectively to control the additional radiation exposures (over the background exposure) expected to be caused by those situations — these are called *practices*;

- ***De facto situations***, where protection can be undertaken a posteriori, i.e. after the fact, when the events causing the exposure have already occurred, by averting part of the existing exposures as much as possible under the prevailing circumstances — these are *interventions*.

Practices involve situations where, given the decision to introduce a justified activity involving radiation exposure, i.e. an activity having positive marginal benefits, the international standards require the control of the additional dose by which such a practice is expected to increase to the extant dose. In this way, the standards control only the additional dose that is attributable to the practice in question, rather than the total dose that an individual is receiving.

In the case of a de facto situation (i.e. a situation which exists, whose causes cannot be controlled in advance), the standards require an intervention, if justified, in order to reduce the extant doses. The objective in this case is to avert doses. Once again, the standards operate through a delta dose; however, in this case it is a negative delta and is termed the averted dose. For intervention, the standards do not refer to the extant dose. They require: “to intervene if justifiable” and “to avert doses as much as reasonably achievable”. As a result, intervention requires doses to be reduced as much as can be reasonably achievable without limitations.

The consequent discussion from the above topics is the scope of radiation safety regulations. Two fundamental and distinct concepts come into play:

- Exclusion of exposures from regulatory instruments;

- Exemption of particular radiation sources from some regulatory requirements.

An exposure is deemed to be excluded from regulatory instruments if its magnitude or likelihood is essentially unamenable to control through regulatory standards. The characteristic of an excluded exposure is not whether or not it is of concern, but rather that the exposure is simply unamenable to management or control through regulations, i.e. there is little or nothing that can be reasonably be done to control them.

Situations of radiation exposure that are not excluded from the regulations can nevertheless still be exempted from some of their requirements. The condition for exemptions is that the expected radiation exposures should be trivial. Numerical exemption criteria and subsequently deduced exemption levels can be derived for different circumstances.

- The additional individual dose attributable to the exempted source should be of the order of 10 μSv per year or less; and

- Either the collective dose to be committed by one year of performance of the practice should not be more than about 1 man-Sievert or exemption should be the optimum option.

There are no international exemption criteria for interventions. The ICRP has recommended the use of intervention exemption levels in order to avoid unnecessary restrictions in international trade of commodities containing radioactive substances, especially foodstuffs.

3. THE CASE OF NORM INDUSTRIES

Public exposure in NORM industries is mainly a result of processing, recycling, storage and disposal of residues [1]. In contrast to the nuclear industries, the presence of radioactivity in these industries is often incidental to the use to which the material is being put. Another aspect is that some of the NORM residues (wastes) have foreseen uses (e.g. phosphogypsum and coal ash) different from those observed in the nuclear industries. Scenarios in which significant exposures to members of the public can take place can easily be developed, leading to the violation of exemption levels.

According to Ref. [4] these situations are different from those involving artificial radionuclides where the concept of triviality has been used to decide on the extent of regulatory involvement. The differences are:

- The industries and processes have often been operating for many years and may predate systems of radiological protection that were introduced, at least initially, for protection against artificial radionuclides;

- The possibility of significant changes in exposure rates, particularly increases, may be automatically limited by a number of factors including plant throughput, the natural upper bound on the activity concentration of the raw material, and workplace legislation controlling the concentration of airborne dust.

One approach would be to exclude these industries from regulations unless the activity levels in the materials used were such that the doses being received were sufficiently high to cause concern. Another approach follows from a decision that specified industries should be subject to regulation, i.e. that they constitute a practice in the context of the Basic Safety Standards [3]. In such cases, a provision for exemption from regulatory requirements may be useful, but the conditions for such exemption would need to be defined. According to Ref. [4], the concept of triviality of the additional dose could no longer be applied; the condition could, for example, be established on the basis that exemption is the optimum option for radiation protection. However reasonable this might be from a theoretical perspective, it could be seen as applying different standards for situations involving artificial radionuclides and involving NORM. For this reason, some have proposed that NORM industries should be regulated in the same way as nuclear related industries. This would mean that for most wastes from NORM industries, exemption would not be appropriate because exposures due to NORM are not trivial.

As mentioned above, the regulatory structure for exempting or releasing from radiological control is based on the principle of triviality of individual doses to members of the public. The ICRP criterion of some “tens of microsieverts” became ten microsievert or less in the IAEA in the IAEA Safety Series No 89 which was created at a time when NORM was unknown or, at any rate, not considered. The same criterion was later used for two regulatory concepts: exemption (from entering regulation) and clearance (for release from regulations), with generally a factor ten higher activity concentration values for exemption as for clearance. The difference in activity levels was explained by ‘quantities’, exemption being applied to small (moderate) quantities and clearance to large quantities. In practice, small meant say 1 to 10 tonnes, while in European studies on (clearance for) recycling, the figure of 10 000 tonnes has been used to exemplify ‘large quantities’. The huge quantities of NORM (2 to 3 orders of magnitude larger than those used in the European studies on nuclear recycling), its activity levels and the large number of industries involved, are being or have been mapped. It has been obvious that the concept of triviality could no longer be used.

For instance, the European Commission, in their Basic Safety Standards [5], propose to solve this problem by dividing occurrences of radioactivity into:

- Practices, which utilize the radioactive properties of materials, i.e. the nuclear industry;
- Work activities, where radioactivity is incidental (NORM industries).

The EC-BSS prescribes an individual dose constraint of 10 μSv/a/practice for the nuclear industry. It is not clear in the BSS what is proposed for the NORM industries. Both in Germany and in Holland, however, the level of 1 mSv/year individual dose is being used.

As observed by Menon [6], a radionuclide at a given concentration can either determine that the material in which it is present be sent to deep geological disposal or released for use in road repair, depending on whether it came from the nuclear industry or a non-nuclear (NORM) one. The author points out that 61 million tonnes of coal ash were generated in the USA by thermal power production in 1990. Such ash is either disposed of or utilized for various industrial applications (more than half for the production of concrete and cement). About 6 million tonnes of coal ash is exempted from regulation by the USEPA for use in building materials. The resulting individual dose to members of the public can be about 100 μSv/a. The distribution in 1990 between the two alternatives was about 80% disposal to 20% utilization. The American Coal Ash Association hopes to ultimately reverse this distribution to 20% disposal and 80% utilization. It is pointed out that such a high utilization rate is technically achievable, as rates up to 70% utilization are not uncommon in Europe.

These figures have an important bearing on commercial aspects (costs), since both coal and nuclear energy are important sources of electricity. It is argued that the double standard system for clearance/exemption may impact the option for one or another generation source, because of the costs involved in the waste management.

The challenge here is to ensure a message to the public is not sent that a ‘double standards system’ is taking place, implying the release of radioactive material with stringent individual dose levels for material from the nuclear industry and a (at least) 100 times higher allowable individual dose resulting from the release of similar material from (NORM) non-nuclear industries.

The associated risk to NORM is also considered when regulation is considered. The US National Academy of Sciences has examined the risks involved in NORM materials. The committee did not find any evidence that the properties of NORM differ from the properties of any other radionuclide in ways that would necessitate the development of different approaches to risk assessment [7]. The study also revealed that, in regard to radiological properties, there is no plausible rationale for any difference in risks due to ionizing radiation arising from naturally occurring and any other radionuclides, because absorbed dose in tissue depends only on the radiation type and its energy, not on the source of the radiation.

The level of regulation would vary depending upon the potential risks to the workers and the public (a graded approach) and for industries where the risks due to radiation are low and where the source or practice is inherently safe, and where a notification by the operator or owner to the regulatory body that the practice and its waste exist may be sufficient.

4. DOSE CRITERIA AND SCREENING LEVELS

Generally speaking, it is always much easier for regulators to have levels to compare with instead of working with dose values that will demand the development of environmental assessments and calculations. The levels may be given in terms of activity concentration of the radioactive materials involved in a specific activity and can be either generic or specified for particular types of activities. Generic levels are necessarily more restrictive. All activities involving radioactive materials with activity concentrations below such a reference level can be eliminated from further consideration, whereas the others have to be included in the regulatory system. For example, in the United States provision was made available to develop an exemption level for TENORM based on decades of documentation and experience with hazards associated with uranium mill tailings. An exemption level of 185mBq/g (5 pCi/g) was fixed with respect to any combination of ^{226}Ra and ^{228}Ra so as to remain consistent with 40 CFR 192 which established this value as a cleanup level for uranium mill tailings [8].

As a second option, the reference level may be established as a dose criterion. Its direct application requires an exposure analysis specific to a particular activity. This approach offers the advantage of a realistic risk assessment as a prerequisite for reasonable decisions on the management of radiation protection, provided that the exposure scenarios and models are adequately selected. Additionally, reference levels of the first type may be applied as screening levels before an exposure analysis is carried out, to eliminate those work activities that are no concern. In Germany, the basic dose criterion applied to a site specific realistic exposure analysis for deciding on the necessity of restoration of a former uranium mining and milling site is 1 mSv/a. A screening level for the unrestricted use of 0.2 Bq/g A^* was established (A^* means the radionuclide of the uranium decay chain with the highest activity concentration in the material). According to Ref. [1], this screening level has been oriented at the highest concentrations found in undisturbed natural conditions in relevant region but is not in contradiction to the dose criterion. For specific restricted uses a screening level of 1 Bq/g A^* was established. The adoption of the 1 mSv/a has to do with the practicability of regulations and public acceptance of restoration programmes once the dose criterion is the same as for practices

5. THE BRAZILIAN APPROACH

In Brazil, the National Nuclear Energy Commission (CNEN) is the regulatory authority in the nuclear field. The Commission is in charge of the licensing and control of nuclear installations in the country. CNEN issues Standards (of compulsory character) and carries out inspections to assess compliance to legal requirements. Up to the present moment, NORM industries are not regulated by CNEN. However, it is recognized that no other governmental institution in the country is prepared to assess the consequences of their operation regarding radiological issues. As a result, CNEN has been assessing and preparing reports regarding the consequences of the operation of NORM industries (mainly mining and milling industries) since the 1980s in response to requests from other state and federal organizations.

In 1994, CNEN decide to develop the Mining Project. The project was coordinated by its Institute of Radiation Protection and Dosimetry (IRD) and was addressed to assess the potential radiological impacts of different non-uranium mining industries. The examined industries involved phosphate, niobium, coal and gold mining and milling plants. Both occupational and environmental impacts were assessed in the operational and post-operational scenarios. A detailed characterization of the operational process was carried out in each of the industries studied. The results of this project are summarized elsewhere [9].

The main conclusions were:

- The most important radiological issues were associated with the wastes/residues, especially after chemical or pyrometallurgical operations, leading to an increase of natural radionuclide concentrations in the generated wastes by two orders of magnitude in comparison with the original concentration in the ore;

- Liquid discharges into the environment were not of concern, because the effluent treatments addressing the non-radioactive pollutants were effective in reducing the radionuclide emissions to non-significant levels;

- Despite the above conclusion, acid mine (rock) drainage proved to be an important mechanism of radionuclide mobilization, being of especial concern in two of the industries studied (coal and gold) [10];

- Changes in the operational process and adoption of improved waste management strategies would lead to the reduction of the potential radiological impacts. Economical recovery of uranium was also indicated as being of potential interest in one of the industries studied;

- Elevated occupational exposures to radon in one of the two coalmines studied were observed. Recent studies with miners of this industry [11] (epidemiological assessment of a cohort of miners) showed an increased mortality rate associated with lung cancer amongst the workers studied. The increase in lung-cancer rates is probably associated with the high radon levels in the underground galleries. Potential exposures to gamma radiation as a consequence of the high radionuclides concentrations in the slags of two niobium industries were also assessed;

- It was not possible to establish a correlation between the radionuclide concentrations in the ore and the radiological impacts. Variable exposure scenarios, represented by extremely different socioeconomic conditions amongst the different regions of the country, were of special concern regarding dose estimates. This finding is of key relevance in trying to define clearance/exemption levels based on generic exposure situations;

- Finally, the use of some of the NORM residues/wastes as building material has the potential to imply doses to members of the general public higher than 100 mSv/a, precluding the material from unrestricted use.

Two subsequent studies [12,13] regarding the use of phosphogypsum (PG) in agriculture and as a building material were carried out. These showed no major radiological consequences related to the use of PG in either situation.

These studies led to the elaboration of the CNEN NE.4.01 Standard [14] (currently under approval procedures). The Standard applies only to mining industries (uranium mining and milling are excluded since they are considered in Brazil to be nuclear installations). Industries can be classified into three categories. Category I involves those facilities which present, at any point of the operational process, radioactive substances with activity concentration higher than 500 Bq/g or doses to members of the public and workers higher than 1.0 mSv/a. Category II industries are those in which the radioactive substances are in the range of 10 to 500 Bq/g. Finally, the Category III industries are those which deal with radioactive substances below 10 Bq/g and doses below 1.0 mSv/a. According to the category in which the industry is classified, it may be subjected to different levels of requirements, that may even approach those requested in the licensing of uranium mining and milling industries. The idea is to exempt those industries falling in category III. However, every industry shall submit to CNEN a set of preliminary information involving:

(i) A simplified operational flow sheet;

(ii) Levels of the relevant radionuclides in the ore, residues, wastes and effluents;

(iii) Mass balance;

(iv) Solubility of radionuclides in the wastes;

(v) A description of the waste management strategies (dams, impoundments, piles, etc);

(vi) A simplified description of the neighborhoods. In situations in which the operations have been terminated and cleanup may be needed, the Standard incorporates the principle of intervention.

The ranges proposed by the ICRP 82 [15] are incorporated into the Standard. The intervention level of 1000 Bq/m^3 of radon is also incorporated into the Standard.

As explained above, CNEN has no legal authority to control these industries. Because of this, the Standard has no compulsory effect. However, and as a result of an agreement between the Ministry of Mines and Energy and CNEN, the federal mining authority (National Department of the Mineral Production – DNPM) is planning to apply the requirements contained in the Standard to control mining activities in the country with respect to radiological issues. A similar agreement is also underway with Ministry of the Environment.

The weak aspects of the Standard are that it does not cover the use of residues/by-products and does not address industries that are not classified as mining activities. A consequence of this is that specific standards will have to be put in place to deal with other NORM industries. Definitely this is not the best course of action.

Along with the development of CNEN-NE-4.01 [14], an instrument called 'Regulatory Position' is in development regarding the oil-gas industry. This instrument takes advantage of the existence of two Standards of CNEN, addressing the licensing of radioactive installations and waste management in radioactive installations, CNEN-NE-6.02 [15] and CNEN-NE.6.05 [16] respectively. The criterion of exemption contained in the first Standard declares that installations that present substances with activity concentrations below 100 Bq/g or naturally occurring radioactive substances with activity concentration below 500 Bq/g are exempted from further regulatory control. If an industry does not comply with these criteria it will be treated as a radioactive installation. The result is that an oil production plant, in which radioactive scales are stored, may turn out to be a radioactive installation if the activity concentration of Ra-isotopes in the material exceeds the exemption level. The Standard CNEN-NE-6.05 [16] defines criteria for the release of wastes into public sanitary fills. The clearance level is 75 Bq/g. However, this level was not conceived for NORM wastes and it is inappropriate to use Standards elaborated mainly for medical installations, for example, to NORM industries, taking into consideration that the amount of wastes generated are completely different in both situations.

6. FINAL CONSIDERATIONS

From what was discussed above it can be seen that it is absolutely necessary and very important that some degree of consistency may be put in place regarding regulatory requirements involving nuclear and NORM industries. It was shown that the absence of this level of equity might impose commercial constraints to the nuclear sector. However, one has to recognize the intrinsic difficulties in trying to achieve this consistency because the radiation protection system was not developed to embrace the NORM industries; on the contrary it was designed to deal with the artificial radionuclides.

One has also to recognize that any regulation of enhanced exposures to natural radiation sources may have large social, economic and political consequences. As proposed by Kraus [1] one should start with reducing the most significant exposures to natural sources. In this sense, the following issues must be considered:

- Definition of applicable technological cost-effective solutions to be used in the management and disposal of large amounts of NORM wastes. Public acceptance of the available solutions shall be considered.

- Adoption of the concept of intervention to deal with the cleanup of NORM contaminated areas. Cost x Benefit analysis and risk based decisions would represent key elements in the discussions of the best strategy to be adopted in a case-by-case basis with the affected communities.

- In contrast with the nuclear industries, NORM industries do not need to be regulated as a whole. The significant operations regarding exposures of the workforce and potential radiological impacts into the environment shall be detected and appropriate measures put in place.

- Models for assessment of exposure to NORM materials could possibly be improved. It must be kept in mind that information obtained for a set of conditions may be inappropriate for other exposure situations involving substantially different environmental and socioeconomic characteristics. Also observed is an urgent need to simulate the release of radionuclides from the wastes (in the process of environmental impact assessment). Varying chemical and physical forms of NORM wastes could also affect the estimates of dose from ingestion and inhalation.

- It is frequently argued that there has been little or no international harmonization yet in respect to NORM regulations. If it is true, care must be taken in order to consider the differences in socioeconomic realities amongst the different nations. It is clear that the level of protection should be, in principle, the same, irrespective of the social conditions of a human being. However, when social targets require larger amounts of resources that may not be available, there is only one-way to proceed: establish priorities among the objectives and make decisions based of cost x benefit analysis. Also of importance is the fact that national guidelines are not used as trade barriers.

- Finally, one of the main problems associated with NORM industries is that the industries concerned are often not aware of its presence in the product, by-product or the waste. To overcome this situation it is important that educational programs are put in place. These should include workshops, written material and on the job training.

REFERENCES

[1] KRAUS, W., Protection against enhanced levels of natural radiation: concepts and regulatory approaches. High Levels of Natural Radiation and Radon Areas: Radiation Dose and Health Effects, Eds. W. Burkart, M. Sohrabi, A. Bayer, Elsevier Science B.V, Amsterdam, (2002) pp. 291–300.

[2] GONZÁLES, A., Current International Issues in Radiation Safety: Regulating Low Level Radiation; Exclusion and Exemption; Clean-up Criteria; Orphan Sources, 31st Annual National Conference on Radiation Control, Louisville Conference, Radiation Control Program Directors, Inc, Frankfort (1999) pp. 1–18.

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

[4] COOPER, J, GONZÁLEZ, A., LINSLEY, G., WRIXON, T., What Waste is ‘Radioactive’? Defining the scope of the regulatory system, IAEA Bulletin 42/3/2000. IAEA, Vienna (2000) pp. 35–44.

[5] EUROPEAN COMMISSION, Laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation, Council Directive 96/29/Euratom, EU, Brussels 1996.

[6] MENON, S., A Nuclear Decommissioner’s Views on the Regulation of TENORM, Waste Management 01 Conference Proceedings, WM Symposia, Inc, Tucson (2001).

[7] US NATIONAL ACADEMY OF SCIENCES, Evaluation of Guidelines for Exposure to Technologically Enhanced Naturally Occurring Radioactive Materials, National Academy Press, Washington (1999).

[8] CONFERENCE OF RADIATION CONTROL PROGRAM DIRECTORS, INC., Part N Regulation and Licensing of Technically Enhanced Naturally Occurring Radioactive Materials (TENORM), Radiation Control Program Directors, Inc, Frankfort (1999).

[9] PIRES DO RIO, M.A., AMARAL, E.C.S., FERNANDES, H.M.E., ROCHEDO, E.R.R., Environmental impact associated with non-uranium mining industries: a proposal for screening criteria, Journal of Environmental Radioactivity 59 (2002) pp. 1–17.

[10] FERNANDES, H.M., FRANKLIN, M.R., Acid Mine Drainage as an important mechanism of natural radiation enhancement in mining areas, IAEA-TECDOC-1271, Proceedings of an International Symposium Technologically Enhanced Natural Radiation (TENR II), Rio de Janeiro, IAEA, Vienna (2002) pp. 39–44.

[11] VEIGA, L.H.S, MELO, V., KOIFMAN, S, AMARAL, E.C.S., High Radon Exposure in Brazilian Underground Coal Mine, Journal of Radiological Protection 2 (2004) pp. 295–305.

[12] COSTA SILVA, L.H., Aspectos Econômico-Ambientais do Uso do Fosfogesso na Agricultura.Tese de Mestrado. Coordenação dos Programas de pós-graduação em Engenharia(COPPE), Universidade Federal do Rio de Janeiro, 122p (1997) (in Portuguese)

[13] ROSA, R., Exposição Potencial a Radiação Natural no Interior de Residências Devido ao Uso do Fosfogesso na Industria da Construção Civil. Tese de Mestrado. Instituto de Biofísica Carlo Chagas Filho, Universidade Federal do Rio de Janeiro, 122p (1997) (in Portuguese).

[14] BRAZILIAN NUCLEAR ENERGY COMMISSION (CNEN), CNEN-NE-4.01, Requisitos de Segurança e Proteção Radiológica para Instalações Minero-Indsutriais (www.cnen.gov.br) (in Portuguese).
[15] BRAZILIAN NUCLEAR ENERGY COMMISSION (CNEN), CNEN-NE-6.02, Licenciamento de Instalações Radiativas (www.cnen.gov.br) (in Portuguese).
[16] BRAZILIAN NUCLEAR ENERGY COMMISSION (CNEN), CNEN-NE-6.05, Gerência de Rejeitos Radioativos em Instalações Radiativas (www.cnen.gov.br) (in Portuguese).

REGULATION AND MANAGEMENT OF NORM RESIDUES IN BULGARIA — CURRENT STATUS AND CHALLENGES

C. NECHEVA
State Enterprise 'Radioactive Waste', Bulgaria

Abstract

The main origin of the environmental residues containing NORM in Bulgaria is the uranium industry developed in the past. The management of NORM residues is implemented within the framework of environmental management. The legal and institutional framework for implementation of the national policy on the NORM residues has been established, by introducing new legislation in accordance with the recommendations of the IAEA and EC, aimed at development of an effective national regulatory and management system.

1. INTRODUCTION

Sites contaminated with NORM in Bulgaria have been investigated and the main problems identified [1]. The major source for radioactive contamination of large areas is the uranium industry, including more than 40 mining sites (classical underground mines, in-situ leaching and combined methods/systems) and operation of two hydrometallurgy processing plants. Since 1994 the uranium industry has been ceased by stages and the state program on uranium industry's consequences liquidation has been developed. The measures undertaken are directed towards environmental recovery and elimination of health hazards for the population in the regions assessed as being the most radiologically hazardous. The program is in the process of implementation and of extension of scope, aimed at decreasing and preventing the risks for human health and the environment [2–4].

A case of interest is the Black Sea Bay of Vromos, as an example of contamination with poly-metallic ore including uranium due to copper mining. The contaminated area has been restored by means of ore processing and metal extraction.

2. LEGAL AND INSTITUTIONAL FRAMEWORK

The management of NORM containing residues is the subject of the National Environmental Strategy and Action Plan, based on the principle of integration of the environmental policy into the branch policies on energy, industry, agriculture, etc. [3, 4]. The priorities are:

- Finalization of technical liquidation of uranium mining and milling sites;
- Carrying out a proper technical and biological re-cultivation with regard to the future use of agricultural land and forestry;
- Conducting of complex and systematic monitoring of the affected regions;
- Complex purification of contaminated water, discharging from the regions of the uranium industry's sites;
- Detailed evaluation and application of the necessary rehabilitation measures in the regions with industrial and research mining sites that are not included into the current program.

The main legal framework for implementation of the national policy regarding the NORM containing residues is determined by the following laws:

- Act on the Safe Use of Nuclear Energy;
- Act on Environmental Protection;
- Act on Health.

The Regulation on the Basic Norms for Radiation Protection introduces the basic principles for radiation protection and the concepts of exclusion, exemption and clearance for the regulatory control purposes, and specifies the excluded exposure, the dose limits for personnel and population, and the exemption levels. The national basic norms are in compliance with the International BSS [5].

The Regulation on the Radiation Protection during Activities with Sources of Ionizing Radiation specifies the organizational and technical rules for conformity with the established basic norms for radiation protection, including rules for clearance. The clearance levels entering into force are in compliance with the recommendations of RS-G-1.7 [6] and include:

- 0.5 Bq/g for radionuclides of natural origin from the natural decay chains headed by ^{238}U, ^{235}U or ^{232}Th. The value is to be applied to each decay product in the chains, including the parents in secular equilibrium;
- General clearance levels for radionuclides of artificial origin;
- Nuclide mass specific clearance levels for metal scrap recycling in compliance with RP89 [7].

The assessment of the radionuclides activity concentration compliance with the clearance levels on the basis of approved methods and measurements is required.

The Council of Ministers adopts the regulations for applying the laws and adopts the national strategies on environment and on the safe management of radioactive waste.

The Ministry of Energy and Energy Resources carries out the policy for the uranium industry's liquidation consequences and for management of radioactive waste. The state owned company Ecoengineering-RM is responsible for the organization and control of the state program for liquidation activities under the governmental decree on the liquidation of uranium mining and milling consequences. An advisory council reviews the liquidation programs, Terms of Reference and projects, and proposes them to the Ministry for approval. Members of the council are representatives of the ministries of environment and waters, of health, of finances, of agriculture and forestry and of the Nuclear Regulatory Agency.

The Nuclear Regulatory Agency carries out the state regulation of the safe use of ionizing radiation and of safe management of radioactive waste, and issues permits and licenses for implementation of activities in this field, including for decommissioning or closure of the relevant facilities.

The Ministry of Environment and Water carries out the national policy and strategy for environmental protection, controls environmental components and the factors having impact upon them, and issues decisions on environmental impact assessment.

The Ministry of Health carries out the state health control, organizes the radiation protection measures for the public, including in chronic exposure situations due to production, trade or use of raw materials, products and commodities with enhanced radionuclide content, and permits the use of the decommissioned sites with sources of ionizing radiation for other purposes.

3. CHALLENGES

During the recent years, the national legislation concerning the NORM containing residues has been changed according to recommendations of the International Atomic Energy Agency and European Commission. New laws and regulations, including the above mentioned, and guides for implementation of the legislative requirements are in process of entering into force or development. In this connection the development of an effective national regulatory system, including different legislative consistency requirements, is the main challenge for the NORM residues management in the country. This approach will result in harmonization with the international practices, and in improvement of the adequacy of the measures undertaken and of the quality of the activities implemented. The development of international cooperation and provision of the necessary financing are the basic means to achieve these goals.

REFERENCES

[1] INTERNTIONAL ATOMIC ENERGY AGENCY, Planning for environmental restoration of radioactively contaminated sites in central and eastern Europe, Volume 1: Identification and characterization of contaminated sites, IAEA-TECDOC-865, IAEA, Vienna (1996).

[2] BULGARIAN GOVERNMENT, National Report on the Fulfillment of the Obligations of the Republic of Bulgaria on the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Sofia (2003).

[3] BULGARIAN GOVERNMENT, National Strategy for the Environment and Action Plan 2000–2006, Sofia (2001).

[4] BULGARIAN GOVERNMENT, Draft of National Strategy for the Environment and Action Plan 2005–209, (2004).

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

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Concepts of Exclusion, Exemption and Clearance Safety Guide, RS-G-1.7, IAEA, Vienna (2004).

[7] EUROPEAN COMMISSION, Recommended radiological protection criteria for the recycling of metals from the dismantling of nuclear installations, Radiation Protection 89, ISBN 92-828-3284-8, EU, Luxemburg (1998).

STUDIES ON NORMS IN CUBA: RESULTS AND PERSPECTIVE

J. TOMÁS ZERQUERA[1], M. PRENDES ALONSO[1],
O. RAMOS BILTRES[1], J. RODOLFO QUEVEDO[2]
[1]Centre for Radiation Protection and Hygiene, Havana, Cuba
[2]National Centre for Nuclear Safety, Havana, Cuba

Abstract

The following scenarios of exposures to NORM have been studied in Cuba: processing and use of phosphates; extraction, processing and use of oil and gas; production of refractory bricks for industrial ovens; civilian aviation; spas and health resorts and scrap metal recycling. Some of these activities have been characterized exhaustively, and others only partially. Some scenarios of exposure to NORM have associated doses comparable with typical doses received by workers of several practices (in the order of units of mSv/year). In this connection some recommendations were issued to the Regulatory Authority in order to establish a regulatory approach to the problem of exposures to NORM. Some problems associated with NORM in the recycling industry remain unsolved, waiting for a more detailed characterization of the by-products involved.

1. INTRODUCTION

The problem of NORM in Cuba is relatively recent. The first systematic studies on radiological impact to members of the public due to the use of phosphates as fertilizers and the oil industry were carried out in the middle of nineties. At the same time, as result of studies made by the Centre for Radiation Protection and Hygiene (CPHR), in coordination with the National Centre for Nuclear Safety (CNSN), on the radiation doses to the Cuban population due to natural sources in the frame of a research project finished in 2000, doses to certain groups of people were found to be comparable with values of radiation doses typical for occupational exposures. In this connection, in 2002 a new research project was launched with the aim of identifying those activities that could be associated with exposures to enhanced natural radiation sources and of assessing in more detail the magnitude of doses associated with those activities.

The results obtained from these studies, together with a briefing on what is being done at present and the perspective of studies on NORM are presented in this paper.

2. SOME RESULTS

In Cuba the following scenarios have been identified as exposure to NORM:

- Processing and use of phosphates;
- Extraction, processing and use of oil and gas;
- Production of refractory bricks for industrial ovens;
- Civilian aviation;
- Spas and health resorts;
- Scrap metal recycling.

During more than eight years, specialists of the Centre for Radiation Protection and Hygiene of the Republic of Cuba have been studying these scenarios. In some cases, when the activities associated with one scenario are carried out at small scale, these activities have been characterized exhaustively. In other cases, some activities or scenarios have been completely characterized and other ones only partially. The results of completed studies follow. In some cases, the radiological impact has been evaluated for both workers and members of the public.

2.1. Processing and use of phosphates

From the six existing Cuban deposits of phosphates, the two that were being actively exploited were studied. Those deposits are the so called ‘La Pimienta’ deposit, located in the western part of the country and ‘Trinidad de Guedes’ deposit, located in the centre-west of Cuba. Phosphates from both deposits are used as fertilizers. In the case of La Pimienta, the mineral is used directly as fertilizer after milling, whereas in the case of Trinidad de Guedes, the mineral is milled and added to a mixture of materials for producing an NPK fertilizer. Phosphates from La Pimienta have been used for several years as fertilizer of citrus cultures in the west of the country. Fertilizers produced using the phosphates from Trinidad de Guedes are used in sugar cane and potato cultures as well as for fertilizing grass for pasture for livestock.

TABLE I. RANGE OF MEASURED CONCENTRATIONS OF NATURAL RADIONUCLIDES IN COLLECTED PHOSPHATES SAMPLES (Bq/Kg)

Location	**^{226}Ra**	**^{232}Th**	**^{40}K**
La Pimienta	1400 – 2700	16 – 39	203 – 238
Trinidad de Guedes	92 – 800	<2.8 – 14	27 – 140

Table I shows the results of determinations of radionuclides collected in the sites samples. Based on these results and taking into account both the features of routine works carried out in the sites and the later use of collected mineral as fertilizer, doses to mining workers and to members of the public were estimated. Dose estimations are shown in Table II.

TABLE II. DOSE ESTIMATIONS FOR WORKERS AND MEMBERS OF THE PUBLIC DUE TO PHOSPHATES OBTAINED FROM THE STUDIED SITES

Location	**Workers (mSv/year)**	**Public (µSv/year)**
La Pimienta	1.40 – 2.70	<17
Trinidad de Guedes	0.3 – 2.5	<1.3

2.2. Extraction, processing and use of oil and gas

Studies on NORM in these activities have been carried out only partially. From the activities mentioned (extraction, processing and use) only the extraction of oil has been studied (and with a limited scope), while the remainder remains unstudied.

The oil industry in Cuba has a territorial organization. For oil extraction the country is divided into three main sectors: west, centre and east. For each of these sectors there is one state company in charge of the extraction of oil and gas. Studies on NORM were carried out in an extraction site located in the western sector, near Havana, known as 'Boca de Jaruco'.

For the assessment, a group of 40 workers involved in extracting activities were provided with personal thermoluminiscent dosimeters for three one-month periods. Results of dosimetric evaluations allowed the doses received by the studied workers to be evaluated, and were found to be in the range 0.3–1.3 mSv/year. No other studies have been made in this kind of scenario.

2.3. Production of refractory bricks for industrial ovens

The main activity linked with the industry of refractory building materials in Cuba is the production of refractory bricks for industrial ovens. Prior to this study, early measurements of building materials were carried out in the country in the middle of the nineties, when significant amounts of natural radioactivity (mainly members of ^{232}Th series) were observed in materials used for the production of refractory bricks.

With the aim of assessing the potential radiological impact of the production of these bricks on workers and member of the public, a series of measurements was organized in one of the biggest refractory brick factories in the country, located in the village of Calabazar, in the outskirts of Havana.

Results of the measurements of gamma dose rate are shown in Table III. Background measurements were made 50 to 100 meters away from the places studied. The measurements of the gamma dose rate were carried out 5 cm from the surface of packages of bricks.

TABLE III. RESULTS OF GAMMA DOSE RATE MEASUREMENTS MADE ON REFRACTORY BRICKS PACKAGES IN CALABAZAR´S BRICKS FACTORY

Measurement place	Gamma dose rate (nGy/h)
Background	**37**
Package No. 1	**49**
Package No. 2	**78**
Package No. 3	**102**
Package No. 4	**102**
Package No. 5	**79**
Package No. 6	**64**

Dose estimations for workers, assuming a 44 hours working week during 48 weeks in a year, yield a range of doses of 0.08–0.2 mSv/year. Taking into account these values for workers it was considered unnecessary to make further dose evaluations for members of the public.

2.4. Civilian aviation

Doses to members of the civil aviation crews were assessed with the cooperation of the Cuban Civilian Aeronautical Institute (IACC), through its Medical Department. Several wooden boxes containing thermoluminiscent dosimeters were put in a fixed place aboard DC-10 planes of the Cuban national airline CUBANA for one-month periods during four months. All box was used together to monitor a single plane, and so all the information regarding the composition of the crews and the specifics of each performed flight (duration, mean altitude, etc.) was recorded. On the basis of data published in other studies (see UNSCEAR 2000 Report) on differences between the doses due to different components of cosmic radiation, an estimation of the total dose to a generic crew member was made, for some established routes and for some working periods. Table 4 and 5 shows the results of such estimations.

TABLE IV. DOSE ESTIMATIONS FOR DIFFERENT ROUTES OF CUBANA PLANES

Flight	Route	Estimated Total Dose (µSv)
470	HAV-LPA-MAD	90
361	EZE-HAV	76
471	MAD-HAV	88
470	HAV-MAD	76
471	MAD-SCU-HAV	89
350	HAV-GRU	76
351	GRU-HAV	70
360	HAV-EZE	75
440	SCU-ORY	78
441	ORY-SCU	84
442	HAV-ORY	84
443	ORY-SCU	86

NOTE: CODE OF AIRPORTS: HAV- HAVANA, SCU – SANTIAGO DE CUBA, ORY – PARIS, MAD – MADRID, EZE – BUENOS AIRES; GRU – SAO PAULO.

Based on an estimation of 300 hours of flight per year as an average and considering the results shown, the mean annual dose of a generic crew member was estimated to be 2.3 mSv.

TABLE V. DOSE ASSESSMENT FOR FOUR CREW MEMBERS PARTICIPATING IN DIFFERENT COMBINATIONS OF ROUTES DURING THEIR WORK
(PERIOD: MAY – JUNE, 2002)

Surname(1)	**Time of flight**	**Total dose (μSv)**
Del Llano	16 h 40 min	152
Garrote	17 h 20 min	164
Rodríguez	19 h 3 min	180
Granados	26 h 9 min	244

(1) Surnames are fictitious; they have been assigned to real people only for differentiation purposes.

2.5. Spas and health resorts

According to a report of the National Group of Thermalism (GNT), Cuba has almost ten sites with thermal spring waters that are used for health care purposes. From these sites, the site known as 'Elguea', located in the centre-east of the country, is one of the most visited by people for health treatments. This health resort is the only one studied until today, and an ongoing national project is complementing the studies already carried out there.

Elguea has an interesting situation. It is located in a wide flat area near the north coast in the Cuban province of Villa Clara. This area is a very low background area, in the middle of which Eleguea arises as a 'hot spot' place, due to the emergence of hot spring waters (50^o – 75^oC) with a high content of ^{226}Ra and sulphides. As the place is used by visitors only for short periods of time, it was decided to focus attention mainly on personnel working permanently in the health facilities.

Due to the presence of ^{226}Ra in the waters, in Elguea both external and internal exposure situations can be found. Measurements of gamma dose rate in the facilities and outside the buildings range from 0.15 – 0.35 μSv/h. A peak of 260 μSv/h was found at a salt deposit. Significant specific concentrations of ^{222}Rn (about 25 Bq/m^3 indoors) were also measured.

Dose estimations were made on the assumption of a working time of 880 h/year. For this time, doses were found to be in the range 0.21 – 3.1 mSv/year due to both external irradiation and inhalation.

2.6. Scrap metal recycling

For more than two years, the Centre for Radiation Protection and Hygiene (CPHR) has carried out the control of scrap metal for recycling for the two main exporters of scrap materials of the country. Even though there is not sufficient information for making a dose assessment, it is important to point out that during this period some pieces containing scales with significant concentrations of NORM have been found in the scrap. Two valves and one piece of a pipeline, all coming from an important industry in the east of the country, were collected during the period of monitoring.

At the same time another interesting form of NORM has been found in the country. In Cuba an important percentage of electricity is generated in thermal plants powered by burning native petroleum. As a by-product obtained from this process, significant amounts of ashes are produced with a high concentration of vanadium. This fact makes these ashes very interesting for the recycling industry abroad. However, these ashes also contain ^{226}Ra in concentrations not permitted for export. It raises an unsolved problem at the present: several tonnes of these ashes could be produced in the future and a solution should be found for them.

3. REGULATORY APPROACH

In 2003 a joint CNSN–CPHR project was completed. Among the NORM scenarios existing in the country, it identified those that should become the object of some kind of regulation. Table 6 shows a comparison between typical dose values associated with some practices in the country and values found for some relevant NORM scenarios.

Table VI: TYPICAL DOSE VALUES ASSOCIATED WITH PRACTICES IN CUBA AND DOSE ESTIMATIONS MADE FOR SOME SCENARIOS OF EXPOSURE TO NORM

Activity	**Associated dose (mSv/year)**
X-ray diagnosis	0.41 – 2.32
Food irradiation	0.63 – 2.6
Production of radiopharmaceuticals	2.52
Research	1.37
Radiation protection activities	1.39
Phosphates mining	0.3 – 2.7
Health resorts work	0.21 – 3.1
Civilian aviation	2.3
Oil extraction	0.3 – 1.3
Production of refractory bricks	0.08 – 0.2

Based on the results obtained, and taking into account the existence of exposure to NORM, scenarios with associated doses above 1 mSv/year, the following recommendations were addressed to the Regulatory Authority in the final report of the above project:

(1) The convenience of considering the activities ‘phosphates mining’, ‘health resorts work’ and ‘civilian aviation’ as practices which could require notification should be considered;

(2) For accomplishing the recommendation 1, it could be necessary in each concrete scenario to make a more detailed characterization, taking into account the Regulatory Authority’s criterion;

(3) The monitoring of individual doses for those activities or scenarios in which doses above 6 mSv/year are expected should be organized.

4. CONCLUSIONS

Several scenarios of exposures to NORM have been identified in Cuba: processing and use of phosphates; extraction, processing and use of oil and gas; production of refractory bricks for industrial ovens; civilian aviation; spas and health resorts; and scrap metal recycling. Some of these activities have been characterized exhaustively, and another ones only partially.

Dose assessments made for the activities associated with the processing and use of phosphates show results of doses in the range 0.3 to 2.7 mSv/year for workers and less than 17 μSv/year for members of the public. For the case of oil extraction activities, the associated doses for workers of oil industry range between 0.3 and 1.3 mSv/year. No other studies have been made in this kind of scenario. A study carried out in a refractory bricks factory yielded dose results in the range 0.08 to 0.2 mSv/year for workers. Doses for crew members of one Cuban airline were assessed and they resulted in 2.3 mSv/year for 300 hours of flight per year. An assessment of doses to workers of one health resort showed doses between 0.21 and 3.1 mSv/year due to both external irradiation and inhalation. Some problems associated with NORM in the recycling industry remain unsolved, and are waiting for a more detailed characterization.

Some scenarios of exposure to NORM have associated doses comparable to typical doses received by workers of several practices. In this connection some recommendations were issued to the Regulatory Authority in order to establish a regulatory approach to the problem of exposures to NORM.

CONTROL OF RESIDUES CONTAINING NATURALLY OCCURRING RADIOACTIVE MATERIAL IN GERMANY

K. GEHRCKE, J. GERLER, E. ETTENHUBER
Federal Office for Radiation Protection, Salzgitter, Germany

Abstract

According to Directive 96/29/EURATOM, the EU Member States are obliged to identify work activities that might lead to a significant increase in exposure due to natural occurring radioactive materials (NORM). In Germany, investigations have been carried out resulting in a list of relevant residues from industrial processes that may cause increased exposure to the general public by their utilization or disposal. Unless the mass specific activities are below certain control levels, these residues require control according to the Radiation Protection Ordinance.

Authorization is not required for dealing with these residues, but they have to be formally released from control by the responsible radiation protection authority prior to their utilization or disposal. This requires that the resulting dose to members of the public be less than 1 mSv per year.

Three years of experience with these regulations have shown both their principal aptness to deal with the problem of radiation exposure caused by NORM, but also some more or less important problems. For example, there are inconsistencies between the NORM regulations and the regulations for the shipment of dangerous goods, both on the national and international levels. Also, a variety of practical problems have to be solved - from the availability of suitable disposal sites to the question of representative sample taking and measurement.

1. BASICS

Directive 96/29/EURATOM has set down a framework for controlling exposures to natural radiation sources arising from work activities, where natural radionuclides are not or have not been processed in view of their radioactive, fissile, or fertile properties [1]. The European Union (EU) Member States are obliged to identify, by means of surveys or any other appropriate measure, work activities that could lead to a significant increase in exposure for workers or members of the public due to the presence of natural radiation sources. This includes industries where materials, ores or minerals are used, or residues arise, that contain enhanced levels of naturally occurring radioactivity (naturally occurring radioactive material - NORM). Appropriate measures have to be taken for these work activities to monitor and, if necessary, to reduce exposure.

According to these EU Basic Safety Standards, systematic investigations have been carried out to find out which materials, industrial processes and work places might be of concern in Germany.

Thereby it was important to distinguish between normal natural exposure on the one hand, and significant increments by work activities and industrial materials and residues on the other. According to the recommendation [2], an annual effective dose of 1 mSv, in addition to the natural background has been chosen as the criterion. It is, however, hardly feasible to check all industrial materials with regard to the radiation exposures that might result from their handling, use or disposal. Therefore, an additional criterion of specific activity of 0.2 Bq/g was introduced to facilitate the investigations. It applies to the radionuclides having the maximum specific activity within the decay series of ^{238}U, and ^{232}Th, respectively. The value corresponds to the upper range of specific activity of these radionuclides in soils in

Germany. It has already been used in order to identify mining residues that can be of concern for radiation protection reasons [3]. Radiation exposures in excess of 1 mSv/a are unlikely below this level. It can serve as a general exclusion criterion for these radionuclides.

Numerous materials and industrial processes have been checked with regard to their potential to cause significant exposure to members of the public on the basis of existing information on mass specific activities in materials; the principal relevance of the industrial processes in Germany; the amount of materials; and their usage or disposal conditions [4].

As a result of this investigation, it has been stated that radiation exposures superseding an effective dose of 1 mSv/a may arise only from the reuse or disposal of a number of industrial residues.

Only radionuclides from the uranium-radium and the thorium decay series have been considered. Potassium-40 (^{40}K) is of minor importance, since internal exposure due to this radionuclide is confined by human metabolism, and external exposure turned out to be negligible with respect to the relevant residues and processes in Germany.

The investigations have led to a list of residues from industrial processes that may cause exposures to members of the public above 1 mSv/a, thus putting these residues within the scope of the German Radiation Protection Ordinance (RPO).

2. MAIN CONTENTS OF THE REGULATIONS

Residues that require control are [5]:

(1) Sludges and scales from oil and natural gas production;

(2) Impure phosphogypsum, sludges from the production as well as dust and slags from the processing of raw phosphate (phosphorite);

(3) (a) Waste rock, sludges, sands, slags and dusts

from the extraction and preparation of bauxite, columbite, pyrochlore, microlite, euxenite, copper shale, tin, rare earths and uranium ores,

from the processing of concentrates and residues that arise during the extraction and preparation of these ores and minerals as well as,

(b) Minerals corresponding to the above specified ores that occur with the extraction and preparation of other raw materials;

(4) Dust and sludges from the off-gas cleaning of blast furnaces in raw iron and non-ferrous metal processing.

However, these residues do not require control if

— they are introduced into those processes as raw materials; or
— the mass specific activity of each of the radionuclides of the ^{238}U and ^{232}Th decay series is less than 0.2 Bq/g.

Also, control is not required as long as the mass specific activities of the listed residues are lower than the control limits specified in the ordinance. They refer to the sum of the specific activities of those radionuclides from the ^{238}U and ^{232}Th decay series showing the maximum values within the respective series:

$$C_{U238_{\max}} + C_{Th232_{\max}} \leq C$$

C takes on values between 0.2 Bq/g and 5 Bq/g, depending on the type and characteristics of the disposal or reuse, respectively. These values have been derived from the level of effective dose of 1 mSv/a, using generic exposure scenarios, parameters and models.

In case the control limit for the intended disposal or reuse option is exceeded, the residue has to be formally released by the radiation protection authority at the request of the responsible person or company. The precondition is, again, that the effective dose to members of the public be less than the reference dose level of 1 mSv/a.

Site specific dose assessments may, however, become rather complex, time consuming, and expensive, especially if the water path is relevant. The regulations offer a simpler approach to release if the controlled residues are to be disposed of together with other residues or wastes. In this case, which has great importance in practice, the following condition has to be fulfilled:

$$C^{av}_{U238_{\max}} + C^{av}_{Th232_{\max}} \leq C^{av}$$

where $C^{av}_{U238_{\max}}$ and $C^{av}_{Th232_{\max}}$ represent the average specific activity of all material disposed of on that site within 12 months. C^{av} takes on values between 0.05 Bq/g for surface disposal when the area of the site is more than 15 hectares, and 5 Bq/g for underground disposal.

However, this approach is restricted to residues with specific activities smaller than 10 Bq/g or 50 Bq/g, respectively. Thereby, the latter value is valid for special disposal sites for residues requiring particular monitoring according to waste law. Above these values, dose assessments are obligatory.

If site specific exposure assessments have to be carried out, realistic exposure scenarios and parameters are explicitly required instead of the conservative ones used in the conventional radiation protection of planned practices.

In contrast to the regulations for practices, authorization is not required for dealing with NORM residues. The concept is mainly based on self-regulation of the industries. If the control limits are not exceeded, the radiation protection authorities will not even have to be informed about the disposal or reuse, unless the amount of residues arising is greater than 2000 tonnes per year. In that case the company has to make a declaration of the type, amount, and specific activity of the residues and the reuse or disposal measures.

A principal drawback of a predefined list of relevant residues is the fact that it might not necessarily be complete. To overcome this problem, the regulations include a paragraph that requires the responsible authority to order protective measures for the reuse or disposal of other materials if it turns out that significant exposures (>1mSv/a) may result from them.

3. APPLICATION EXPERIENCES

Example: Residues from oil and natural gas extraction

The radioactivity of scales and sludges results from connate waters that often contain barium, strontium and radium, depending on the kind of rock formation of the reservoir. Radium isotopes co-precipitate with barite due to their chemical similarity to barium. Consequently, the radioactivity of scales and sludges results primarily from radium.

In Germany, an annual amount of 10 000 tonnes of scrap containing about 1000 tonnes of scales arises from the oil and gas extraction industry. The specific activities of the radionuclides vary considerably. In scales, for instance, mass specific activities of ^{226}Ra range up to 1000 Bq/g. Although mean values are usually much lower, the specific activities are mostly well above the highest control limit of 5 Bq/g, which is valid for underground disposal. Therefore, these residues have to be released from control by the authority prior to disposal.

Several disposal options are available. If the overall specific activity of the tubes including the scales is less than 50 Bq/g, dumping of the untreated tubes according to the mixture formula is possible. The growing demand for metal scrap has, however, led to a preference of technologies where the steel is recycled, both after the removal of the scales or the smelter of the contaminated tubes. If the scales are removed, the radionuclides, as well as other toxic substances, can be fixed, using geopolymers, for instance. In this fixed form, the contributions of all paths other than external exposures are reduced to negligible values. Resulting radiation exposures are well below 1 mSv/a for all workers involved in the process.

3.1 Impacts on industry

As a result of the regulations on work activities and NORM residues, many people and companies are confronted with problems of radioactivity and radiation protection for the first time. Since the personnel are normally not qualified in radiation protection issues and no measurement equipment is available, professional assistance is usually necessary to deal with these problems. Meanwhile some consulting companies have specialized in this field. Assistance is also given via guidelines, provided by authorities and industrial associations. Thus, despite the fact that there are still some problems to be solved, many industries directly concerned with the regulations have already found, or are in the process of finding, solutions of how to deal with controlled residues.

However, the increasing public awareness of natural radioactivity has led to a situation where even industries that are not directly affected by the regulations are forced to deal with the problem. For instance, there is a trend for customers to inquire about the radioactivity content of materials and residues. Quality certificates of raw materials and chemicals increasingly include information about natural radioactivity. Also, disposal sites are partly equipped with radiation monitors and reject residues or wastes with enhanced radioactivity levels. Hence, practical problems, the general uncertainty about how to deal with radioactivity and also fears of image loss make some companies treat materials containing NORM as if they were controlled residues, even if there is no legal obligation to do so. In a water works, for example, 20 tonnes of gravel filter containing 1.2 Bq/g ^{226}Ra had to be disposed of. Although there was no legal obligation, the operator, as a food supplier, insisted on disposing the material according to the regulations of the RPO.

3.2. Some practical problems

The specification of residues, which are generally within the scope of the regulations, has turned out to be a suitable instrument to confine the regulatory and practical effort with respect to NORM residues. Nonetheless, experiences show that it could be necessary to update the list from time to time, because industrial processes are subject to changes in raw materials, technologies, or even dying out. On the other hand, some possibly important materials have not been specified as controlled residues. Therefore, the paragraph of the RPO dealing with "other materials needing control" is getting more significance than expected.

Sometimes it is difficult to decide whether certain materials are within the scope of the regulations or not, because some of the definitions turned out to be not precise enough. For instance, residues from "the extraction and preparation of bauxite" mainly meant huge amounts of so called red mud disposed of in tailings ponds covering millions of tonnes. Now, the question has arisen of whether so called blast bauxite, which has specific activities of a little more than 1 Bq/g (sum of the representative nuclides of both relevant decay series) and is used in relatively small amounts, has to be dealt with as controlled residue or not. Clearly, this was not the intention of the regulations, but they could well be interpreted this way. As with the example of a water works mentioned above, many industries generally tend to carefully follow the NORM regulations if in doubt, be it just to avoid image problems.

Several problems may arise also regarding the disposal sites. Although residues are no longer radioactive in the sense of the RPO after having been released from control, disposal operators are often reluctant to accept such materials for general fears of radioactivity. Ironically, it is precisely the release procedure that gives rise to this problem. It becomes especially important when the released residues have to be declared as 'radioactive' in the sense of the regulations for the carriage of dangerous goods (see below).

In view of the legal consequences it is also important that the necessary measurements be carried out using generally accepted, standardized methods, models, and parameters. For instance, the NORM regulations require a representative determination of mass specific activities of the relevant radionuclides. Therefore, the German Commission on Radiological Protection prepares recommendations for that [6]. Moreover, as spectrometric laboratories are normally not available in the NORM industries, simple measurement methods based on dosimeters and contamination monitors are being developed. Measurements by these instruments do not need high qualifications. They can be used for a variety of applications, if the radionuclide composition is known, at least for repeated measurements.

In addition, calculation provisions are in preparation to be applied for the realistic dose assessments required. These provisions will be based on those already in use for the radiological evaluation of mining residues [7].

4. REGULATORY INCONSISTENCIES

As already mentioned above, there are regulatory inconsistencies concerning the carriage of dangerous goods on road, subject to the so called ADR regulations [8] and the NORM regulations of the RPO. The problems that are associated with this will be illustrated using data and information from a disposal project of tubing from the oil and gas extraction. The measured specific activities of the radionuclides of the scales and the calculated average values for the whole tubes are shown in the following table.

TABLE 1. MASS SPECIFIC ACTIVITIES OF RADIONUCLIDES IN TUBES FROM OIL AND GAS EXTRACTION

Radionuclide	Specific activity (scale) [Bq/g]	Specific activity (tube with scale) [Bq/g]
^{226}Ra	510	120
^{228}Ra	170	40
^{228}Th	190	45
^{210}Pb	105	25

One of the disposal options already mentioned is the direct disposal of the tubes including the scales. It can be shown that the resulting radiation exposure for members of the public is less than 1mSv/a, which means that the residues can be released from control for that specific disposal option.

However, the disposal facility is not authorized to accept radioactive materials according to the ADR, class 7. The limit of specific activity for the application of the regulations is 100 Bq/g for ^{226}Ra, ^{228}Ra and ^{210}Pb and 10 Bq/g for ^{228}Th, provided that use of the radionuclides is not intended. In the case of radionuclide mixtures, lower limits have to be applied according to the following formula

$$X_m = \frac{1}{\sum_i \frac{f(i)}{X(i)}}$$

where $f(i)$ are the fractions of specific activity of nuclide *i*, and $X(i)$ the corresponding limits for the particular nuclides.

The limits of the ADR regulations are exceeded in any case. Hence, although the residues are released from control according to the RPO, they are 'radioactive' in the sense of the ADR and can therefore not be disposed of at that specific facility under the conditions described.

This example shows the need to harmonize the different regulations in order to avoid inconsistencies.

In Germany, regulations on reclamation sites contaminated with residues from old practices and work activities are in preparation. In order to avoid further inconsistencies, it is necessary to carefully adjust the new regulations with the existing regulations on NORM. Otherwise residues that are released from control today might require intervention tomorrow. This is particularly important because the types of materials covered by both regulations are partly the same, as in the case of waste rock from uranium ore production.

5. SUMMARY

Since 2001, materials containing NORM are within the scope of the German Radiation Protection Ordinance. The basic concept of the NORM regulations, in contrast to those for practices, is that only those residues explicitly specified in the regulations are within the scope. However, if the control limits of mass specific activity specified in the regulations are not exceeded, no control is necessary.

To avoid undue regulatory effort, the regulations rely to a large extent on self-control of the concerned industries. Authorization is not required for dealing with controlled residues, but they have to be formally released from control by the responsible radiation protection authority prior to their reuse or disposal. This requires the resulting dose to members of the public to be less than 1 mSv per year.

Three years of experience with these regulations have shown their principal aptness to deal with the problem of radiation exposure caused by NORM. Although many companies have been confronted for the first time with radioactivity problems, many industries that are concerned with the regulations have found, or are in the process of finding, solutions to properly deal with controlled residues. The regulations have led to a greater awareness in industry with regard to NORM and the specific radiation protection issues. Generally, industries tend to care about radiation protection even if they are not obliged to do so, be it just to avoid image problems.

There are still some problems to be solved. For example, there are inconsistencies between the NORM regulations and the regulations for the carriage of dangerous goods. Also, a number of practical problems have to be solved - from the availability of suitable disposal sites to the question of representative sampling and measurement.

REFERENCES

[1] EUROPEAN COMMISSION, Council Directive 96/29/EURATOM, Basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation, EU, Brussels, (1996).

[2] EUROPEAN COMMISSION, Recommendations for the implementation of Title VII of the European Basic Safety Standards Directive (BSS) concerning significant increase in exposure to natural radiation sources, Radiation Protection 88, EU, Brussels (1997).

[3] ETTENHUBER, E., GEHRCKE, K., Radiologische Erfassung, Untersuchung und Bewertung bergbaulicher Altlasten — Abschlussbericht, Bundesamt für Strahlenschutz, Salzgitter (2001).

[4] BARTHEL, R. ET AL., Ableitung von Überwachungsgrenzen für Reststoffe mit erhöhten Konzentrationen natürlicher Radioaktivität, Brenk Systemplanung GmbH, Aachen (1999).

[5] GERMAN FEDERAL GOVERNMENT, Verordnung über den Schutz vor Schäden durch ionisierende Strahlen (Strahlenschutzverordnung) (2001), BGLBl. I S. 1869, 1903 (2002).

[6] BARTHEL, R., Grundsätze und Methoden zur Ermittlung repräsentativer Werte der spezifischen Aktivität unter Berücksichtigung von statistischen Unsicherheiten, Empfehlungen der Deutschen Strahlenschutzkommission (to be published).

[7] GERMAN FEDERAL MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY, Calculation Provision for the Estimation of Radiation Exposures Caused by Mining-Related Environmental Radioactivity (1999).

[8] EUROPEAN COMMISSION, European Agreement Concerning the International Carriage of Dangerous Goods by Road, EU, Brussels (2001).

MANAGMENT AND REGULATION OF RESIDUES CONTAINING NORM IN GREECE

V. KOUKOULIOU
Greek Atomic Energy Commission,
Department of Environmental Radioactivity, Attica, Greece

Abstract

The paper describes the current regulatory regime in Greece as it relates to radioactive waste management and NORM in particular. The present radioactive waste management policy is explained and the discussion shows how this policy is applied, using the phosphate fertilizer industry as a case study.

1. REGULATORY FRAMEWORK

1.1 Waste management

The Greek regulations for the waste management are in accordance with the relevant European Union Directives, such as:

- Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, Official Journal L 182, 16/07/1999 p. 0001–0019.

- 2003/33/EC: Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC.

- Commission Regulation (EC) No 2557/2001 of 28 December 2001 amending Annex V of Council Regulation (EEC) No 259/93 on the supervision and control of shipments of waste within, into and out of the European Community.

The owner of the waste (industry) is obliged to submit a study concerning the environmental impact depending on the disposal option or the reuse of the material. The study must include all the relevant industry data, raw materials, wastes, by-products and the study of many environmental parameters based on specific criteria and/or test methods and associated limit values for each landfill class, including if necessary specific types of landfills within each class, as mentioned in the relevant regulations.

The environmental impact study is submitted to the Ministry of Environment or to the local Prefecture or to the relevant Municipality (depending on the extent of the project). Also many other authorities may be involved in the authorization and licensing process, such as the Ministry of Defense, the Ministry of Health, the Greek Atomic Energy Commission (GAEC) (in case of radioactive waste), the Bureau of Antiquities, etc.

All these authorities prepare a judgment concerning the submitted study of the environmental impact. The final authorization is given by the Ministry of Environment, the local Prefecture or the relevant Municipality.

The waste management options in Greece are:

- Recycling (metals, glass, paper, aluminum);
- Reuse (wood, etc);
- Landfill;
- Specific disposal sites for hazardous waste (not yet constructed, in progress);
- Incineration (only for wastes arising from hospitals);
- Fuel material (a percentage of waste with high thermogenic power could be used as fuel for the industry, such as cement industries);
- Disposal into the sea, rivers and lakes is not permitted.

2. RADIOACTIVE WASTE MANAGEMENT POLICY

Radioactive waste in Greece originates from medicine, research and industry. The management of radioactive waste is carried out on the site of origin. The national policy for the radioactive waste produced in research and medical applications is the decay storage and discharge. Since 1990, according to Greek legislation, an import licence for a radioactive sealed source is only granted by the regulatory authority, the Greek Atomic Energy Commission (GAEC), under the condition that the foreign supplier certifies to take back the source when it is disused.

Since 2001, there is a new legislation in Greece, the Joint Ministerial Order 1014 (ΦΟΡ) 94, Official Gazette No 216/B/6-03-2001 'Radiation Protection Regulations', which concerns the civilian applications of the ionizing radiation. This legislation implements the International Atomic Energy Agency (IAEA) [1] and European Union (EU) Basic Safety Standards [2].

The producers of radioactive waste have to bear full costs of treatment, interim storage and final disposal. On-site waste treatment includes a range of operations, such as waste segregation, characterization, conditioning (only waste produced at the National Centre for Scientific Research (NCSR) 'Demokritos'), storage and disposal. The national policy for the waste produced in research and medical applications is the decay storage and discharge.

For the spent and disused sealed sources, a programme of collecting them from the users' premises has been begun about a year ago. This programme provides for the collection of all spent and disused sources imported into Greece before 1990, at the Institute of Nuclear Technology and Radiation Protection (INT-RP), NCSR 'Demokritos', where the know-how and relevant infrastructure exist. Most of the sources with relatively high activity have already been collected from the users' premises. It is expected that this programme will be completed within a year. The intention is to export disused sources. Since 1990, according to Greek legislation, a radioactive source in order to be imported into the country must have the commitment of the supplier to take back the source when it becomes disused. Therefore, when the supplier makes an offer, he takes into account that in a few years' time he will have to undertake the cost of taking the source back. In light of the arrangement described above, concerning the spent and disused sealed sources issue, there is no need to create a long-term storage or disposal facility.

2.1. NORM residues

At that moment there are no specific waste management regulations concerning NORM residues. These materials (such phosphogypsum, fly ash, etc) are also included at the general regulatory framework for waste management. For example, according to the Commission Regulation (EC) No 259/93 "on the supervision and control of shipments of waste within, into and out of the European Community", phosphogypsum belongs to the green catalogue of wastes. For the disposal or reuse of this material a study of the environmental impact is also required according to the specific criteria that are established in the EU Directives, as already explained at the previous section. A lot of environmental parameters, such as characterization of waste, soil & groundwater chemical analysis, heavy metals (Cr, Cd, Pb, etc), rainfall data, study of soil permeability, discharges to the environment and air quality, are considered to ensure they fulfill the relevant regulations, although there are no specific requirements for the impact of natural radionuclides.

According to the New Greek Regulations for Radiation Protection (No. 216B, 5/3/2001), which is in accordance with the 96/29/EURATOM 31/5/1996 [2], criteria have been established for 'work activities' working with NORM, for the effective dose (except radon) and for radon. These dose criteria are applicable to workers.

In the New Greek Regulations for Radiation Protection it is clearly mentioned that the presence of natural radiation sources that leads to a significant increase in the exposure of workers or of members of the public cannot be disregarded from the radiation protection point of view. The Greek Atomic Energy Commission is the regulatory authority responsible for the identification, by means of surveys or by any other appropriate means, of work activities that may be of concern. These include, in particular:

(a) Work activities where workers and, where appropriate, members of the public are exposed to thoron or radon daughters or gamma radiation or any other exposure in workplaces such as spas, caves, mines, underground workplaces and aboveground workplaces in identified areas;

(b) Work activities involving operations with, and storage of, materials not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of workers and, where appropriate, members of the public; and

(c) Work activities that lead to the production of residues not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of members of the public and, where appropriate, workers.

Based on the last paragraph the Greek Atomic Energy Commission tries to evaluate the data concerning NORM residues.

For the management of NORM residues, the basic reference is the EU publication:

— Radiation Protection 122 "Practical Use of the Concepts of Clearance and Exemption – Part II, Application of the Concepts of Exemption and Clearance to Natural Radiation Sources", EC 2001 [3].

According to this recommendation, the proposed dose criterion is 300 μSv/a. This criterion should be regarded as an increment to the exposure, which would prevail in the absence of the work activity. This is not a strict criterion but, according to each scenario pathway and taking in account the basic principles of As Low as Reasonably Achievable (ALARA) and optimization, the dose criterion could be much lower.

In the case, for example, of phosphogypsum disposal for agricultural purposes, the concentration of 400 Bq/kg as an upper limit, was calculated based on a dose criterion of 10 μSv/a for the specific exposure pathway, namely the ingestion of rice produced in a phosphogypsum enriched soil.

The derived limits are specific for a particular manner of disposal (for example phosphogypsum for agriculture).

2.2. Work activities under investigation

The main work activities in Greece which may lead to a significant increase in the exposure of the workers or members of the public and where the residues produced may need specific authorization from radiation protection point of view are: (a) mines and quarries, (b) phosphate industry, (d) cement production (e) oil and gas, (f) lignite power plants.

Until now, we have identified as 'work activities':

— Two fertilizer production industries that are located in northern Greece; and

— Factories where repair of aero-engines constructed from Th-Mg alloy are performed. Thorium is added to magnesium to produce a hardened, light alloy for use in turbine engine components. Such alloys may have a ^{232}Th activity up to 160 Bq/g.

The disposal and reuse of all NORM residues arising from these work activities should be authorized by GAEC.

3. PHOSPHATE FERTILIZER INDUSTRY

The fertilizer industries are potentially radiologically significant sources of discharges and waste disposals. The two fertilizer industries are regulated by GAEC:

- The main type of waste is solid (phosphogypsum) and it is landfill disposed in the form of stacks or is used for agriculture (saline soil improvement);
- 200 GBq (total activity of ^{226}Ra corresponding to annual phosphogypsum production). The ^{226}Ra concentration of phosphogypsum produced varies between 200 – 700 Bq/kg,
- Each industry produces about 250 000 tonnes of phosphogypsum per year,
- Each industry produces about 250 000 tonnes of fertilizer per year,
- The first fertilizer industry is located in northern Greece near Thessaloniki. The phosphogypsum disposal is at the rice fields of Kalochori and the phosphogypsum stacks are at the industry area and the locality Pentalofo,
- The second fertilizer industry is located in Kavala (Nea Karvali) in northern Greece. The phosphogypsum disposal is a landfill disposal at the industry area.

4. DISPOSAL OF PHOSPHOGYPSUM

Until recently the options for waste disposal in the fertilizer industries were the following:

- Phosphogypsum disposal in stacks;
- Phosphogypsum disposal in open land;
- Use of phosphogypsum for agriculture purposes (saline soil improvement).

After a radiological study performed for the two fertilizer industries and the disposal areas, the GAEC issued, in 2001, an order concerning the safe management of phosphogypsum disposal in Greece. According to GAEC the following terms must be satisfied:

4.1. Disposal of phosphogypsum in the environment

- For phosphogypsum disposal in the environment in the form of stacks, a relevant radiological study is required. The study must be approved by GAEC and the specific disposal requires GAEC's authorization.
- A soil layer must cover phosphogypsum stacks.
- Special care must be given to underground water radium contamination. Radon emanation must be taken into account in case of buildings construction activities in areas where phosphogypsum has been disposed. For all the phosphogypsum disposal areas GAEC must keep a relevant record.

4.2. Use of phosphogypsum for agricultural purposes

In order to assess the doses due to the use of the phosphogypsum for soil improvement, a dosimetric calculation was performed using the following assumptions:

- The dose criterion of 10 μSv/a was chosen as a criterion due to the specific exposure pathway that corresponds to the ingestion of rice produced in a phosphogypsum enriched soil;
- A known quantity of phosphogypsum was dispersed in a rice field with known dimensions;
- The phosphogypsum deposition in the particular field was repeated every 2 years;
- The phosphogypsum was homogenized with a 10 cm layer of soil;
- The critical group was the local population that consumes rice produced in this area;
- The quantity of rice consumed every year was taken for the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report 2000 [4]; and
- The chosen transfer factors of ^{226}Ra from soil to grain used in this calculation were based on the EU publication Radiation Protection 115 [5].

Phosphogypsum may be lawfully removed from a stack and distributed in commerce for use in agriculture if each of the following requirements is satisfied:

- The industry that produces phosphogypsum that will be removed shall determine annually the average ^{226}Ra concentration at the location in the stack from which the phosphogypsum will be removed. The ^{226}Ra concentration measurements must be performed in an authorized laboratory;

- The average ^{226}Ra concentration at the location in the stack from which the phosphogypsum will be removed shall not exceed the 400 Bq/kg;
- All phosphogypsum distributed in commerce for use shall be accompanied by a certification document; and
- Inspections for the ^{226}Ra concentration in soil, water, underground water and agricultural products must be performed on a regular basis in areas where phosphogypsum is used in agriculture.

The methodology for the sampling and measurement of ^{226}Ra, as well as details concerning the certification documents, are described in details in relevant Appendixes.

5. OTHER NORM RESIDUES

For other NORM residues, the Greek Atomic Energy Commission produces a judgment to the Ministry of Environment or to the local Prefecture or to the relevant Municipality (depending on the extent of the project), upon the submitted environmental impact study. Dosimetric calculations are applied based on sample measurements and models describing the specific problem (nature of the waste, quantity, place for disposal, possible pathways for public and workers exposure, etc). One of the main concerns of the radiological study is the U and Ra transfer to underground water. The same approach is also applied for the reuse of the residues. For example, in case of the building materials, the judgment is based on the EU European Commission publication, Radiation Protection 112, “Radiological Protection Principles concerning the Natural Radioactivity of Building Materials”, 1999 [6].

REFERENCES

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

[2] European Commission, Laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation, Council Directive 96/29/Euratom, EU, Brussels (1996).

[3] EUROPEAN COMMISSION, Practical use of the Concepts of Clearance and Exemption – Part I, Guidance on the General Clearance Levels for Practices, Radiation Protection 122, EU, Brussels (2000).

[4] UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION, UNSCEAR Report to the General Assembly of the United Nations 2000, IAEA, Vienna (2000).

[5] EUROPEAN COMMISSION, Investigation of a possible basis for a common approach with regard to restoration of areas affected by lasting exposure as a result of past or old practice or work activity, Radiation Protection 115, EU, Brussels (2000).

[6] EUROPEAN COMMISSION, Radiological protection principles concerning the natural radioactivity of building materials, Radiation Protection 112, EU, Brussels (2000).

REGULATORY AND MANAGEMENT APPROACHES TO NORM RESIDUES IN MALAYSIA

[1]M. OMAR, [2]I.L TENG
[1]Malaysian Institute for Nuclear Technology Research (MINT), Malaysia,
[2]Atomic Energy Licensing Board (AELB), Malaysia

Abstract

Naturally Occurring Radioactive Material (NORM) processing industries in Malaysia include oil and gas production and mineral processing plants. These industries are controlled by the Atomic Energy Licensing Board of Malaysia (AELB) through the enforcement of the Atomic Energy Licensing Act 1984 (Act 304). Related regulations have been developed in order to ensure the safety of workers and members of the public. However, more regulations are necessary for the safe handling of NORM. NORM processing generates various types of NORM residues that require proper management. As for low-level NORM residues, landfill disposal can be exempted from regulatory control if the Radiological Impact Assessment (RIA) shows that the additional dose to the members of the public is below the limit set by the authority. This paper outlines the regulatory and management approaches to NORM residues in Malaysia.

1. INTRODUCTION

Naturally Occurring Radioactive Material (NORM) has received much attention in Malaysia. This is due to the presence of several industries related to NORM. Handling of NORM falls under the jurisdiction of the Atomic Energy Licensing Board of Malaysia (AELB) through the enforcement of the Atomic Energy Licensing Act 1984 [1].

2. TYPES OF NORM RESIDUES

Major NORM residues in Malaysia are sludge and scales from the oil and gas production industry, thorium hydroxide from monazite and xenotime processing to extract rare earth elements, tin slag from tin smelting plants, iron oxide from ilmenite processing for synthetic rutile production through chloride process, red gypsum from ilmenite processing for titanium dioxide (TiO_2) pigment through sulphates process, polishing sludge from the glass panel manufacturing industry and residues from decontamination and decommissioning (D&D) processes of rare earth production plants. As for the residues, the acronym TENORM for Technologically Enhanced Naturally Occurring Radioactive Material is frequently used in Malaysia. Activities related to NORM in Malaysia have been reported recently [2].

2.1. Sludge and scales

At oil and gas production facilities, sludge accumulates in the processing vessels whereas scales are deposited on the interior surface of the production components when there is a temperature or pressure drop. With the introduction of scale inhibitors, less scale accumulates. The volume of sludge generated is substantial. The estimated annual quantity of oil and gas sludge generated in Malaysia is about 900 000 tonnes. Treatment of sludge generates secondary residues such as matured sludge from sludge farming, chemical extraction residues and incineration ash. The radium concentration of the various types of treated and untreated oil and gas industry residues from Malaysia have been reported [3]. The highest mean ^{226}Ra and ^{228}Ra concentrations of 114 and 130 Bq/g, respectively, were measured in scales. However, the volume of the scales generated is small compared to the sludge. Overall, about

75 % of the waste, mostly untreated sludge and residues from chemical extraction of sludge has radioactivity levels similar to those of the normal soils of Malaysia.

2.2. Tin slag

In the tin smelting process, tin ore concentrates from alluvial tin mining containing traces amount of radioactive minerals, such as monazite, zircon, struverite, xenotime and ilmenite, are used as raw materials. In the process, naturally occurring radionuclides get concentrated in smelting residues i.e. tin slag. The concentrations of ^{226}Ra (uranium series) and ^{228}Ra (thorium series) in tin slag are 2 Bq/g and 3 Bq/g respectively [4]. The estimated annual quantity of tin slag residues generated is 10 000 tonnes. The accumulated tin slag is estimated to be 140 000 tonnes by end of the year 2004.

2.3. Thorium hydroxide

Rare earth production industry from xenotime and monazite cracking process operated in Malaysia from 1982 to 1992. Substantial amounts of NORM residues, i.e. thorium hydroxide (190 Bq/g ^{226}Ra, 250 Bq/g ^{228}Ra) from xenotime processing; thorium hydroxide (0.45% U, 15% Th) from monazite processing; lead cake (26 Bq/g ^{226}Ra, 350 Bq/g ^{228}Ra); and tri-calcium phosphates (0.1 Bq/g ^{226}Ra, 0.6 Bq/g ^{228}Ra) [4] were generated. The estimated quantity of thorium hydroxide generated throughout the operation is 12 000 tonnes.

2.4. Gypsum and iron oxide

Titanium dioxide (TiO_2) pigment can be produced from ilmenite or synthetic rutile. Red gypsum (0.1 Bq/g ^{226}Ra, 0.06 Bq/g ^{228}Ra) and iron oxide (0.7 Bq/g ^{226}Ra, 0.9 Bq/g ^{228}Ra) are produced as solid residues [4]. The estimated annual quantity of red gypsum and iron oxide generated are 450 000 tonnes and 8 000 tonnes respectively. The accumulated amounts of red gypsum and iron oxide are estimated to be 3 million tonnes and 120 000 tonnes respectively by end of this year.

2.5. Polishing sludge

In the glass panel manufacturing industry, a small amount of zircon is used. Rouge, pumice and garnet are used in the panel polishing process generating polishing sludge. At the beginning of its operation, the polishing sludge was found to contain 0.06 Bq/g ^{226}Ra and 0.3 Bq/g ^{228}Ra. However, after the modification of the process, the radioactivity content of the polishing sludge has been reduced to 0.04 Bq/g and 0.06 Bq/g of ^{226}Ra and ^{228}Ra respectively. The process is estimated to generate between 6 000 and 10 000 tonnes of sludge annually.

2.6. D&D wastes

The rare earth production industry ceased its operation in the early 1990s due to high competition from other Asian countries and the difficulty in obtaining consistent and sufficient supplies of monazite (raw materials, by-product of tin mining activities) as a result of the slowing down in tin mining industry in Malaysia. The rare earth company is currently conducting D&D processes in the monazite cracking plant. The wastes generated from these process are contaminated equipments and contaminated soils. The estimated volume of the contaminated materials is 50 000 m^3.

3. REGULATORY ASPECTS

The main act used in Malaysia to deal with radioactive materials including NORM is Act 304 [1]. AELB continually develops regulations and guidelines in order to ensure safe handling of NORM.

Under Act 304, the management or disposal of radioactive waste is specifically dealt with under Sections 26-31 of the Atomic Energy Licensing Act 1984. These sections empower the Atomic Energy Licensing Board (AELB) to ensure users (licensees) to obtain appropriate licences prior to dealing with (accumulating, transporting or disposing of) radioactive waste and to take appropriate actions to rectify situations deemed unsafe. These provisions, however, do not provide details on the measures that should be taken by the user.

The Radiation Protection (Basic Safety Standards) Regulations [5] and Radiation Protection (Licensing) Regulations [6] cover all aspects of 'dealing' with radioactive and radiation sources including NORM. Dealing means any activity involving manufacturing, trading, producing, processing, purchasing, owning, using, transporting, transferring, handling, selling, storing, importing or exporting radioactive material. Dealing with NORM requires a licence, either licence Class A (milling of radioactive materials), Class D (transport of radioactive materials) or Class E (Export or import of radioactive materials), Class G (disposal, storage, and decommissioning of milling installation, waste treatment facility), Class H (miscellaneous, e.g. services for decontamination and decommissioning work, treatment of sludge and scales, etc). Together with the licence, the AELB usually issues licence conditions to be fulfilled by the licensees.

Generally, everything is considered radioactive until it has been exempted by the authority. At the moment, there is no common NORM concentration level to define what is radioactive. At the operational level, however, a limit of 0.05 % uranium plus thorium (adopted from [7]) in minerals and ores is used by the AELB for handling such materials. As for the management of sludge and scales from the oil and gas industry, the AELB is in the process of drafting the Code of Practices (CoP). It is common to adopt a control limit based on the Total Activity Concentration (TAC) of ^{226}Ra and ^{228}Ra based on the following formula:

$$TAC = (6 \text{ X } ^{226}Ra) + (8 \text{ X } ^{228}Ra)$$, where ^{226}Ra and ^{228}Ra are the activities in Bq/g.

In principal, if the residues exceed the control limit, they will be controlled by the regulatory agency as TENORM wastes. The wastes will be exempted from the control and can be handled as ordinary hazardous waste if the TAC is below the control limit.

Instead of source radioactivity level, a general approach adopted by the AELB is the use of the annual limit of 1 mSv/a additional dose to the members of the public as the control limit. This means that any activities related to NORM handling such as treatment, reuse and disposal exceeding this control limit would be licensed.

The current practice prior to the approval of a landfill disposal activity is that the licensee should submit a Radiological Impact Assessment (RIA) to the AELB. It is common to undertake the task using a computer code, RESRAD, developed by the Argonne National Laboratory, USA. The RIA should as much as possible use site specific parameters and demonstrate that the doses to the members of the public do not exceed the limit stipulated in the Act or Regulations. In practice, the AELB is using a constraint limit of 0.3 mSv/a. In some cases, it may be necessary to carry out radiological monitoring after the disposal.

Some NORM activities or sludge are exempted from the regulatory control after studies have been made by AELB. The examples of such exemption are the use of zircon for ceramic tile manufacturing [8] and copper slag, mostly for blasting.

Small amang (tin mine tailings) factory (annual dose to a worker <50 mSv/a) is exempted from the provision of the Atomic Energy Licensing Act 1984 on condition that the factory is registered with the AELB and the factory follows the guidelines issued by the AELB (AELA, 1984d). In conjunction with this, two guidelines have been released for the Small Amang Factory, namely Guideline for the Safe Transportation of Radioactive Minerals in the Amang Upgrading Industry [9] and Guideline for Radiation Protection Guide for Small Amang Factory [10]. But there are still no specific guidelines for the handling of mineral residues.

Oil and gas industry residues that contain hazardous and radioactive materials are categorized as scheduled waste by the Department of Environment (DoE) and as radioactive waste by the Atomic Energy Licensing Board. In fact, as a precautionary measure, the AELB has classified the oil and gas industry residues as TENORM waste [11]. A coordinated approach has been agreed whereby the AELB has to declassify the waste from radioactive category before it can be treated at the Hazardous Waste Treatment and Disposal Centre approved by the DoE.

4. MANAGEMENT OF RESIDUES

4.1. Storage and treatment

Storage and treatment of NORM residues require permission from the authority. As the volume of residues from TiO_2 plants is tremendous, iron oxide and red gypsum residues are allowed to be dumped temporarily at companies' premises. Red gypsum and iron oxide have the potential to be used in consumer products, e.g. gypsum in partition walls and iron oxide as red bricks for pavement.

As for the sludge and scales from oil and gas industry, apart from storing in metal drums some companies apply sludge farming method to treat the residues in order to remove the hydrocarbon content through bio-degradation process. This method is simple and cheap but the process is very slow and it requires a large area of land. A chemical extraction method is also used to separate hydrocarbon and to reduce the volume of the sludge. Volume reduction through extraction is very effective. Large scale testing by the Malaysian Institute for Nuclear Technology Research (MINT) and a private company has produced only about 0.1 tonnes of secondary solid residues from the treatment of 100 tonnes of oil sludge. Incineration, as applied by Hazardous Waste Treatment and Disposal Centre, is another potential method to remove the hydrocarbon content of sludge. It is a common practice to return the volume-reduced secondary residues from the treatment process back to the primary residues generator. This clearly shows that there are still problems to solve after treatment.

The polishing sludge was allowed to be treated by conditioning with cement at the Hazardous Waste Treatment and Disposal Centre. The re-utilization of the polishing sludge in the cement manufacturing has also been explored.

The residues from xenotime and monazite processing were stored in drums at the plant premises at the time of its operation. The drums were then transported to an approved storage facility. This facility is a proper building with concrete bays that can hold more than 20 000 tonnes of wastes.

4.2. Landfill disposal

The disposal of NORM residue is still a problem. For low-level activity residues, landfill disposal is one of the potential options. The residues that can be disposed of by landfill include primary residues, such as tin slag, iron oxide and red gypsum, and secondary residues from treatment, such as incineration ash, matured sludge from sludge farming and sediment residues from chemical extraction.

In the past, tin slag was considered an ordinary waste and was used as landfill material in a northern state, where the smelting had been carried out. Recently, tin slag has been realized to contain tantalum, niobium and tungsten and can be sold for extraction of the precious metals. Resale of the residues helps in reducing the volume of the waste. However, the price of the tin slag varies depending on the market demand. Newspapers reported that a local authority had offered a tender to dig out tin slag from a stadium prior to its renovation. As for slag dumped in other area, there was no effort to recover or to intervene. Prior to closing down of one of the tin smelting plants, tin slag was approved to be used for reclaiming a piece of swampy land on which it was planned to build a warehouse.

Contaminated soil and plant components from the rare earth plant D&D were transported to an engineered cell at the approved disposal site. The future plan is to decontaminate and decommission the thorium hydroxide storage facility and dispose of the waste in another engineered cell at the disposal site. The engineered cell has several layers including a geochemical barrier, a geochemical intruder barrier, concrete capping and a soil cover.

5. REMARKS

Clear and sufficient guidelines are required for safe management of NORM residues in order to protect the environment and the people. International cooperation and information sharing are crucial to assist national authority to enforce better regulations.

REFERENCES

[1] ATOMIC ENERGY LICENSING AUTHORITY, Atomic Energy Licensing Act 1984, (Act 304), Atomic Energy Licensing Board (AELB), Kuala Lumpur (1984).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Extent of Environmental Contamination by Naturally Occurring Radioactive Material (NORM) and Technological Options for Mitigation, IAEA Technical Reports Series No. 419, IAEA, Vienna (2003).

[3] OMAR, M., ALI, H.M., ABU, M.P., KONTOL, K.M., AHMAD, Z., AHMAD, S.H.S.S., SULAIMAN, I.,HAMZAH, R., Distribution of radium in oil and gas industry wastes from Malaysia, Applied Radiation and Isotopes, 60 (2004) pp. 779–782.

[4] OMAR, M., The Status of Activities involving NORM in Malaysia, RCA Expert Advisory Group Meeting to Review and Develop Radiation Protection Guidance for Naturally Occurring Radioactive Materials in the Oil and Gas and other Minerals Extraction and Processing Industries, 16–20 Mar., Australian Nuclear Science and Technology Organisation, Sydney (1998).

[5] ATOMIC ENERGY LICENSING AUTHORITY, Radiation Protection (Basic Safety Standards) Regulation 1988: AELB, Kuala Lumpur (1988).

[6] ATOMIC ENERGY LICENSING AUTHORITY, Atomic Energy Licensing (Small Amang Factory) (Exemption) Order, PU(A) 435, AELB, Kuala Lumpur (1984).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection of Workers in Mining and Milling Radioactive Ores 1983 Edition Code of Practice and Technical Addendum, Sponsored by IAEA, ILO, WHO, IAEA Safety Series No. 26, IAEA, Vienna, (1983).
[8] ATOMIC ENERGY LICENSING AUTHORITY, Atomic Energy Licensing (Exemption) (Ceramic Factory) Order 1998, PU(A) 431/1998, AELB, Kuala Lumpur (1998).
[9] ATOMIC ENERGY LICENSING AUTHORITY, Guideline for the Safe Transportation of Radioactive Minerals in the Amang Upgrading Industry (LEM/TEK/32), AELB, Kuala Lumpur (1994).
[10] ATOMIC ENERGY LICENSING AUTHORITY, Guideline for Radiation Protection Guide for Small Amang Factory, LEM/TEK/37, AELB, Kuala Lumpur (1994).
[11] ATOMIC ENERGY LICENSING AUTHORITY, Guideline for Handling and Radiological Monitoring TENORM Waste from Oil and Gas Industry, LEM/TEK/30 Sem.2, AELB, Kuala Lumpur (1996).

REGULATORY APPROACHES FOR NORM RESIDUES IN THE NETHERLANDS

J. VAN DER STEEN
Product Group Radiation & Environment, NRG, Petten, Netherlands

Abstract

The paper describes the background to the development of radiation protection in The Netherlands and then goes on to discuss the issue of NORM residues and waste in detail. In particular the paper emphasizes the pragmatic approach taken by the authorities in developing the safety regulations in relation to natural sources of ionizing radiation. These regulations are explained in some detail together with a description of the range of NORM residues and wastes that are found in The Netherlands. A number of industries are listed with the NORM issues associated with each one being briefly describe as well as being tabulated in an appendix.

1. INTRODUCTION

In May 1996 the Council of the European Union adopted the Council Directive 96/29/Euratom laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation [1]. The Euratom Directive applies to all *practices*, which involve a risk from ionizing radiation emanating from an artificial source or from a natural source in cases where natural radionuclides are processed in view of their radioactive properties. They also apply to *work activities*, which involve the presence of natural radiation sources that cannot be disregarded from a radiation protection point of view.

Title III of the Euratom Directive deals with the system of reporting, authorization and clearance for *practices*. Exemption levels for reporting of practices are specified in Annex 1 of the Euratom Directive, but it is left to the Member States to establish clearance levels for disposal, recycling or reuse of radioactive materials. Apart from some specific practices that always require prior authorization, Member States may define a dividing line between reporting and authorization for other practices.

Title VII of the Euratom Directive specifically addresses enhanced exposures due to natural radiation sources. Each Member State shall ensure the identification by means of surveys or by any other appropriate means, of *work activities* that may be of concern, in particular:

(a) Work activities where workers and, where appropriate, members of the public are exposed to thoron or radon daughters or gamma radiation or any other exposure in workplaces such as spas, caves, mines, underground workplaces and aboveground workplaces in identified areas;

(b) Work activities involving operations with, and storage of, materials, not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of workers and, where appropriate, members of the public;

(c) Work activities that lead to the production of residues not usually regarded as radioactive but which contain naturally occurring radionuclides, causing a significant increase in the exposure of members of the public and, where appropriate, workers;

(d) Aircraft operation.

Moreover, it is specified that Member States may decide on the applicability of all or parts of the relevant Titles, including Title III, for work activities of concern.

These issues are very important for industries dealing with NORM, because they may threaten a harmonized implementation of the Euratom Directive in the legislation of the different Member States. Specifically, the levels for clearance of natural radionuclides have a direct effect on the volumes of waste and residues for which the regulations are applicable. To avoid problems in competition and cross-border transport of materials within the European Union, it should be highly desirable to decide on an internationally agreed approach for disposal options and setting clearance levels. In order to stimulate harmonization, the European Commission has published a guideline to assist Member States in regulating natural radioactive sources [2]. Reference levels for workplaces processing NORM contaminated materials [3] and guidance for natural radioactivity of building materials [4] and for applying the concepts of exemption and clearance to natural radiation sources [5] have also been published. The latter publication (RP122/Part II) contains a table of activity concentrations that is intended as guidance for the Member States in applying these concepts in their national regulations.

Recently, the International Atomic Energy Agency (IAEA) has published a safety guide on the application of the concepts of exclusion, exemption and clearance [6], which also contains a table of activity concentration levels for natural radionuclides.

The Member States have now implemented the Euratom Directive in their national legislation. Despite the guidance documents of the Commission, one can conclude that there are indeed significant differences in the national regulations. This paper describes the regulatory approach for waste and residues with natural radionuclides in the Netherlands and its consequences for the Dutch industry.

2. THE DUTCH RADIATION PROTECTION DECREE

2.1. Methodology for derivation of exemption and clearance levels

The new Dutch Radiation Protection Decree [7] came into force on 1 March 2002. The scope of the Decree does not include:

- Exposure to radon and daughters from undisturbed earth crust, from burning of natural gas and from building materials in buildings;
- Above ground exposure to radionuclides from undisturbed earth crust and from building materials in buildings;
- Naturally occurring radionuclides in the body; and
- Cosmic radiation (except aircrew).

Chapter 8 of the Decree deals with natural sources and work activities that are covered by the regulations. The approach is that all work activities should be reported or licensed when both the total activity and the activity concentration exceed nuclide specific exemption levels. The Decree contains a single table of activity and activity concentration levels for a large number of radionuclides, both of artificial and of natural origin. The values in the table are both for exemption and clearance, so there is no numerical difference between these two concepts. The values for artificial radionuclides are based on Annex 1 of the Euratom Directive (with the exception of ^{60}Co, for which a 10 times lower activity concentration level is specified). For those radionuclides that are not mentioned in Annex 1, the same methodology for derivation of the values has been used, based on an effective dose criterion of 10 μSv per year. However, the values for natural radionuclides have been calculated on the basis of a 300 μSv/a effective dose criterion and using exposure scenarios that are considered to be realistic, but conservative, for the Dutch situation. This dose value, which is approximately the same as the variation of the natural background, is considered as a pragmatic choice in order to avoid regulating a large number of industries without having a beneficial effect on radiation protection. The exemption and clearance levels that are specified in the Radiation Protection Decree are based on several studies carried out for the Dutch Ministry of Housing, Spatial Planning and the Environment [8–11].

2.2. Clearance and exemption levels for natural radionuclides

The Radiation Protection Decree contains a single set of exemption and clearance levels. The values for the natural radionuclides differ considerably from the values that have been established in the guidance document of the European Commission (RP122/II, [5]), which are based on generic exposure scenarios. They are also different from the recently published values in RS-G-1.7 [6]. The values for the most relevant natural radionuclides, in the Dutch Radiation Protection Decree as well as in RP122/II [5] and in RS-G-1.7 [6], are given in Table I.

It is important to notice that work activities are exempted from reporting when either the total activity or the activity concentration is lower than the values in Table I. Since industries use large amounts of materials, the total activity will always exceed the levels specified in the Dutch Radiation Protection Decree. Therefore, the activity concentration is for the process industry the discriminating factor for exemption and clearance.

TABLE I. EXEMPTION/CLEARANCE LEVELS FOR SOME NATURAL RADIONUCLIDES IN THE DUTCH RADIATION PROTECTION DECREE [7], IN RP122/II [5] AND IN RS-G 1.7 [6].

Radionuclide	Dutch decree, Total activity (Bq)	Dutch decree, activity Concentration (Bq/g)	RP122/II (Bq/g)	RS-G-1.7 (Bq/g)
U-238s	1000	1	0.5	1
Th-232s	1000	1	0.5	1
Ra-228+	100 000	1	1	1
Ra-226+	10 000	1	0.5	1
Pb-210+	10 000	100	5	1
Po-210	10 000	100	5	1

For "s" and "+" see Annex I, Table B of the Euratom directive [1]. Summation rule to be applied when more than one radionuclide is present: $\Sigma(C_I/EL_I) < 1$

Many raw materials, residues and waste streams have activity concentrations in the range of a few tenths of a Bq/g to a few Bq/g. Although at first sight the difference between 0.5 and 1 Bq/g seems not to be significant, the consequences of choosing a certain level for clearance and exemption can be very large. For example, a stockpile of millions of tonnes of phosphogypsum with an activity concentration of 0.7 Bq/g ^{226}Ra + should be regulated when the RP112/II [5] level is chosen as a clearance level, or cleared from reporting when the Dutch value is chosen (as well as excluded from the regulations in RS-G-1.7 [6]).

The example shows clearly the difficulty in reaching international agreement in setting national exclusion, exemption and clearance levels. For international trade it would be important to have internationally agreed levels, but for national reasons (social, political, economical), it can be very important to use country specific exposure scenarios and to evaluate the implications of regulatory control, including the net benefit of regulatory control in terms of improved radiation protection. The difference between the activity concentrations in the Dutch decree and RP122/II [5] for ^{210}Po/^{210}Pb is a factor of 20 (and a factor of 100 compared to RS-G-1.7 [6]), but it is believed that the exposure scenarios used for calculation of the values for the main ^{210}Po/^{210}Pb containing waste streams (sludges and scales of the oil and gas production industry) in the Netherlands are more realistic, while those of RP122/II [5] are generic and considered to be overly conservative for the Dutch situation.

2.3. Clearance levels for discharges

The Dutch Radiation Protection Decree contains also a table with clearance levels for aerial and liquid discharges, in terms of GBq per year, as a consequence of work activities. The values for the most relevant radionuclides are given in Table II.

2.4. System of exemption/clearance, reporting and authorization

The system of exemption and clearance, reporting and authorization of work activities, as described in the Dutch Radiation Protection Decree, is summarized in Table III.

TABLE II. CLEARANCE LEVELS FOR AERIAL AND LIQUID DISCHARGES OF NATURAL RADIONUCLIDES AS A CONSEQUENCE OF WORK ACTIVITIES (GBQ/A PER INSTALLATION)

Radionuclide	**Aerial discharge**	**Liquid discharge**
^{238}U	10	1000
^{232}Th	1	100
^{228}Ra	1	100
^{226}Ra	10	10
^{210}Pb	10	10
^{210}Po	10	10

TABLE III. SYSTEM OF EXEMPTION/CLEARANCE, REPORTING AND AUTHORIZATION OF WORK ACTIVITIES IN THE DUTCH RADIATION PROTECTION DECREE

Total activity < EL/CL value	- Exempt/Clear
Total activity ≥ EL/CL value - Concentration < EL/CL value - Concentration ≥ EL/CL value - Concentration ≥ 10 times EL/CL value	 - Exempt/Clear - Report - Authorize

Total discharged activity	
- < EL/CL value	- Clear
- ≥ EL/CL value	- Authorize

3. THE REGULATION OF NATURAL SOURCES OF IONIZING RADIATION

The Dutch Regulation of Natural Sources of Ionizing Radiation [8] is a further stipulation of articles of the Decree, which elaborates on a number of technical issues for work activities. The Regulation contains rules for summation of radionuclides, criteria and rules for surface contamination and its detection, and rules for reporting and authorization. It also contains a list of work activities that have been identified as possibly exceeding the exemption and clearance levels mentioned in Table I.

3.1. Identification of work activities

Identification of work activities with emphasis on occupational exposure has been carried out for the Ministry of Social Affairs and Employment [9,10]. In general, the methodology of Penfold et. al., described in Radiation Protection 107 [11], was followed for these studies. Industries in the Netherlands with potentially significant NORM aspects were identified, based on data from literature, and work activities within these industries were classified with the aid of exposure scenarios for both normal and unlikely conditions. The effective annual doses for workers are calculated using exposure scenarios specific to the type of industry considered. The exposure scenarios are limited to external irradiation and internal contamination by inhalation of dust.

This, together with the results of the calculations in the different studies for the Ministries of Housing, Spatial Planning and the Environment [12–15] gave a clear picture of the industries in the Netherlands where exposure to NORM may not be ignored from a radiological point of view. They showed that, except for exposure of aircraft personnel to cosmic radiation, most exposure situations in the Netherlands are related to the processing of ores, products and residues with enhanced concentrations of natural radioactivity. This is in accordance with data from other studies [15–19], which show that such exposures occur in various types of industry. The list of identified work activities is published as an annex to the Regulation, and can be updated regularly. The most important of these are the phosphate and fertilizer industry, the metal and rare earths production industry, the ceramic industry, the production and use of thoriated materials, the pigment industry and the oil and gas production.

Entrepreneurs carrying out work activities which are mentioned on the list are obliged to verify if they fall under the Regulation, and more specifically if they fall under the reporting or authorization regime. If a work activity is not on the list, this does not mean by definition that the entrepreneur is out of the scope of the regulations. If there is a reasonable suspicion, by the entrepreneur or the regulator, that they might fall under the regime of the regulations, the entrepreneur is obliged to verify this. If yes, this can lead to a revision of the list in the Regulation.

3.2. Criteria for surface contamination

The Regulation contains a third criterion for authorization, which is applicable in those situations where total activity or activity concentration is not practicable. This is the case when thin scales are deposited on the surface of parts of the installation. In those cases this criterion is a better indicator of the radiological risk than the activity-based criteria. For objects with only thin scales of NORM, it is sufficient to measure the surface contamination and to compare it with the exemption/clearance criterion of 4 Bq/cm^2 of beta-activity. If the surface contamination is at or below this value, the object is exempted (or cleared). Above this value, the object needs to be authorized.

The Regulation also describes how the surface contamination should be measured. It is not necessary to measure alpha activity, since the vast majority of contaminated materials contains both alpha and beta emitters (except materials contaminated with pure ^{210}Po). Since in most cases the beta activity is a factor of 3 higher than the alpha activity, the measurement of the beta activity can serve as an indication of both types of radioactivity. In the explanation of the Regulation, arguments are given that the criterion restricts the dose to workers and the public from cleared and exempted materials to doses of no regulatory concern.

3.3. Reuse of residues with natural sources

The Regulation stimulates the reuse of NORM containing residues. To this end, the Regulation contains an article that makes it explicitly possible, in contravention with the interdiction in the Radiation Protection Decree for radioactive waste with artificial radionuclides, to dilute these residues with other residues to decrease the activity concentration for the purpose of reuse.

4. NORM RESIDUES AND WASTES IN THE NETHERLANDS

The most important residues and waste streams from NORM industries in the Netherlands and the approach for management of the residues are summarized in Table IV.

With respect to the sludges from the **oil and gas production industry**, one can conclude that there is no final solution for the management of this waste stream. The activity concentration is varying, but most of the sludge can be considered as reported material or in some cases even as authorized material. The composition of the waste, with organic and heavy metal components, makes it unsuitable for long term storage at the radioactive waste repository site and at the moment there is no work-up process available. Re-injection in abandoned wells is not allowed, as the Dutch government policy forbids waste disposal deep underground.

The activity concentration in the slag from the **phosphorus production industry** is around the reporting level. The slag is used as a road construction material. Doses for road construction workers are estimated to be 0.3 mSv/a under normal working conditions [9,10]. The calcinate, with an activity concentration of 1000 Bq/g ^{210}Po, is clearly authorized material. No reuse is foreseen. The material is being stored at the radioactive waste repository site. This is long-term storage for decay of ^{210}Po. Because of the high temperatures used in the phosphorus production process, much of the ^{210}Po is discharged. The total discharge exceeds the clearance level for discharges; therefore, the discharges are authorized.

Phosphoric acid production has been discontinued in the Netherlands since 2000. The phosphogypsum itself, with a ^{226}Ra content of 0.5 Bq/g, could be considered as cleared material. It has always been discharged as slurry in the Nieuwe Maas, the mouth of the river Rhine. The discharges have been authorized.

The zinc-rich filter cake (blast furnace dust) from the **steel industry** can be categorized as cleared or in some cases reported material. At the moment, this material is not reused, but stored at the site of the industrial plant (approximately 200 000 tonnes). Up to now, there is no disposal route for this waste stream. Precautions are taken to prevent resuspension. The slag is cleared material. It is reused as an additive in cement. The discharges are authorized.

Fly-ash from **coal-fired stations** is cleared material. The mass of fly-ash is roughly 10% of the mass of coal, and since almost all radioactivity of the coal goes into the fly-ash, the concentration factor is about 10. The activity range of coal is rather broad, but in all cases a mix of coal is used for burning. This keeps the activity concentration at a few tenths of a Bq/g. Specific problems may be encountered in maintenance work in the kettle. Scales can have ^{210}Po concentrations of more than 100 Bq/g. This makes it necessary to take precautionary measures to avoid inhalation during maintenance work. The volume of scale, however, is very small and does not create a waste management problem.

Brick production does not create a waste or discharge problem. The (calculated) discharges are about a factor of 10 below the authorization level.

The solid residues of **titanium dioxide** production are mostly categorized as reported material. They have been used as backfill material in landfills.

A specific problem has been encountered during the last years after installing portal monitors at scrap yards in the Netherlands. Since that time, loads with scrap are regularly identified to contain scrap with slag wool that has been used as thermal insulating material. This has been discovered in a wide variety of installations. Examples are insulation doors, bakery ovens, small steam generators and a large coal-fired power plant (Figures 1–5). Radiation exposures at dismantling of slag wool insulated installations are estimated to remain below 2 mSv/a and are dominated by internal exposure due to inhalation of dust. Respiratory protection (Figure 6) reduces the exposures to small doses from external exposure. The most likely origin of this material is **slag from tin production** in the period of about 1946 to 1960. The slag wool contains elevated concentrations of ^{238}U and ^{232}Th, causing the triggering of the portal monitors. The activity concentrations are such that the use and disposal of the material should be authorized in most cases, but large volumes may already have been disposed as non-radioactive waste. Tin refinement has taken place on a large scale in Western Europe in the past, in particular in Spain and the UK. In the latter country, former sites of tin smelters with large inventories of tin slag have been identified and remediated. It is estimated that 30 million tonnes of tin slag with enhanced levels of natural radioactivity have been used in civil engineering [20].

A feasibility study has been carried out to investigate whether the slag wool could be incorporated into the slag of the phosphorus production plant. This is an example in which a residue (a few hundred tonnes per year of slag wool) is diluted with other material (500 000 tonnes per year of phosphate slag) in order to make it possible to reuse the slag wool according to the rules of the Regulation Natural Sources of Ionizing Radiation. A decision is still to be taken, but according to this feasibility study the slag wool could be reused as road construction material.

TABLE IV. CHARACTERISTICS OF AND MANAGEMENT OPTIONS FOR THE MOST IMPORTANT NORM RESIDUES AND WASTES PRODUCED IN THE NETHERLANDS. THE TABLE ALSO INCLUDES DATA ON DISCHARGES

Industry	**Waste / Residue**	**Production rate (ktonne/a)**	**Activity concentration range (Bq/g)**	**Discharges (GBq/a)**		**Management options**
				Aerial	**Liquid**	
Oil and gas production	Sludge	0.1	Up to 25 Ra-226/228; Up to 250 Pb/Po			Reported or authorized material. No reuse foreseen: radioactive waste. No conditioning method for storage at radioactive waste repository. Disposal in abandoned wells forbidden. No final solution.
Phosphorus production	Slag	600	1 U-238 (Pb/Po depleted)			Reported material. Reused for road construction.
	Calcinate	10	1000 Pb-210			Authorized material. No reuse foreseen. Radioactive waste, stored long-term for decay.
				300-800 Po-210; 30-100 Pb-210	30-160 Po-210; 20-70 Pb-210	Authorized.
Phosphoric acid production (discontinued in 2000)	Phosphogypsum (discharged as slurry)	650	0.5 Ra-226		250-380 Ra-226; 230-300 Po-210; 240-340 Pb-210	Cleared material. Discharges authorized.
Steel production	Zinc rich filter cake	10	15-25 Pb-210			Cleared or reported material. Possibly reusable. At the moment stored on-site.
	Slag	1000	0.15 U-238; 0.15 Th-232 (Pb/Po depleted)			Cleared material. Reused in cement production.

Industry	Waste / Residue	Production rate (ktonne/a)	Activity concentration range (Bq/g)	Discharges (GBq/a)		Management options
				Aerial	Liquid	
				Calculated 1990 91 Po-210; 55 Pb-210	Calculated 1990 8 Po-210; 0.5 Pb-210	Discharges authorized.
Electricity production by coal burning	Fly-ash	1000	0.05 - 0.2 U-238; 0.06 - 0.3 Th-232			Cleared material. Reused in cement production.
Brick production		3200	0.035 U-238; 0.035 Th-232	Calculated 1.2 Po-210; 0.2 Pb-210		Discharges cleared from authorization.
Titanium oxide pigment production (chloride process)	Solid residues	10 per 90 ore	Up to 7 U-238; Up to 11 Th-232			Mostly reported material. Used as backfill.
					Calculated 22 Ra-226; 38 Ra-228; 3 Po-210; 9 Pb-210	Figures depend on pH of process. Discharges authorized.
Tin production (historic residues)	Slag wool (used as thermal insulating material or as substrate in greenhouses)	0.5 at present detected	4 U-238; 10 Th-232			Feasibility study for reuse in slag for road construction.

FIG. 1. Two disused ovens from a foundry.

FIG 2. The remains of a boiler.

FIG. 3. A steam generator with slag wool under the corroded area.

FIG. 4. A door insulated with slag wool.

FIG. 5. The front of a large coal fired boiler from a power plant, partly dismantled without appropriate control.

FIG. 6. Outfit for personal protection during dismantling.

5. CONCLUSIONS

The implementation of Title VII of the Euratom Directive in the Dutch regulations has been based on a pragmatic approach. The exemption and clearance levels for natural radionuclides are based on a dose criterion of 300 µSv/a to avoid unnecessary regulation of a large number of industries without any radiological protection benefit. There is no distinction in the numerical values of exemption and clearance levels.

The Dutch exemption and clearance level values differ from the guidance given by the European Commission in RP122/II [5], and also from the IAEA Safety Guide RS-G-1.7 [6]. The differences are caused by the approach taken by the Dutch regulators to use country specific exposure scenarios that are relevant for the Dutch situation, taking into account the implications of regulatory control, including the net benefit of regulatory control in terms of improved radiation protection.

The identification of work activities has given a clear view of the industrial processes that encounter problems with natural radionuclides in the Netherlands. In many cases, the problems are related with the management options for residues and waste streams. For most of the waste streams, pragmatic solutions are possible, without excessive cost for the industry. Large volumes of residues are reused, either as road construction material or as an additive in cement. In the case of slag wool, a feasibility study has been carried out to see whether a pragmatic solution for reuse is possible. For some other waste streams, however, no solution is available at the moment.

Since different countries may have different problems with NORM, due to the character of industrial activities and associated problems with finding pragmatic solutions, a country specific approach seems to be unavoidable. Such an approach makes it possible take into account the resources that are available in a certain country. This is, however, counterproductive for the harmonization of regulations.

Nevertheless, there is a need for international consensus on the approach. In this respect, the publication of the IAEA Safety Guide RS-G-1.7 [6] can be considered as a necessary first step. But apart from the exclusion, exemption and clearance levels, there are also large differences in the approach for waste management. Disposal options vary widely. What is allowed in one country is forbidden in another country. There should be agreement on disposal options, in order to avoid competitive advantages and disadvantages. Disharmony in regulations can lead to suboptimal solutions from a radiological protection point of view. Migration of industries to countries with less stringent regulations does not improve radiation protection.

REFERENCES

[1] OFFICIAL JOURNAL OF THE EUROPEAN COMMUNITIES, L159. Council directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of workers and the general public against the dangers arising from ionising radiation, EU, Brussels (1996).

[2] EUROPEAN COMMISSION, Recommendations for the implementation of Title VII of the European Basic Safety standards Directive concerning significant increase of exposure due to natural radiation sources. Radiation Protection 88, EU, Brussels (1997).

[3] EUROPEAN COMMISSION, Reference levels for workplaces processing materials with enhanced levels of naturally occurring radionuclides. Radiation Protection 95, EU, Brussels (1999).

[4] EUROPEAN COMMISSION, Radiological protection principles concerning the natural radioactivity of building materials. Radiation Protection 112, EU, Brussels (1999).

[5] EUROPEAN COMMISSION, Practical use of the concepts of clearance and exemption - Part II. Application of the concepts of exemption and clearance to natural radiation sources. Radiation Protection 122, EU, Brussels (2001).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Concepts of Exclusion, Exemption and Clearance. Safety Guide No. RS-G-1.7, IAEA, Vienna (2004).

[7] BESLUIT STRALINGSBESCHERMING, Radiation Protection Decree of 16 July 2001, State Journal 397, Dutch Government, The Hague (2001) (in Dutch).

[8] Regeling natuurlijke bronnen van ioniserende straling; Regulation Natural Sources of Ionizing Radiation of 25 August 2004, State Journal 184, Dutch Government, The Hague (2004) (in Dutch).

[9] TIMMERMANS, C.W.M., VAN WEERS, A.W., Inventorization of work activities with exposure to natural radiation sources. Ministry of Social Affairs and Employment, Working document nr 121, The Hague, May 1999 (in Dutch).

[10] TIMMERMANS, C.W.M., VAN WEERS, A.W., Work activities with exposure to natural radiation sources. Update of the inventorization of 1999. Ministry of Social Affairs and Employment, Working document nr 200, The Hague (1999). (In Dutch).

[11] EUROPEAN COMMISSION, Establishment of reference levels for regulatory control of workplaces where minerals are processed which contain enhanced levels of naturally occurring radionuclides. Radiation Protection 107, EU, Brussels (1999).

[12] TIMMERMANS, C.W.M., Scenarios and reference levels for the disposal and reuse of large quantities of residues from the non-nuclear industry. KEMA report 22727-NUC 97-9002, Dutch Government, The Hague (1997).

[13] TIMMERMANS, C.W.M., Conditional clearance levels for the use of residues from the non-nuclear industry as building materials. KEMA report 22892-NUC 98-9002, Dutch Government, The Hague (1998) (in Dutch).

[14] PRUPPERS, M.J.M., BLAAUBOER, R.O., TWENHÖFEL, C.J.W., Research for discharge criteria for licensing according to the Nuclear Energy Act in the process industry. RIVM report nr. 610310002, Bilthoven (1999) (in Dutch).

[15] VAN WEERS, A.W., TIMMERMANS, C.W.M., MEIJNE, E.I.M., Evaluation of the substantiation of proposed clearance levels in the draft Radiation Protection Decree. NRG report 20293/00.31670, Dutch Government, The Hague (2000) (in Dutch).

[16] REICHELT, A., LEHMANN, K-H., Anthropogene Stoffe und Produkte mit natürlichen Radionukliden – Teil 2: Untersuchungen zur Strahlenexposition beim beruflichen Umgang. Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen, Dutch Government, The Hague (1993).

[17] LEENHOUTS, H.P., STOOP, P., VAN TUINEN, S.T., Non-nuclear industries in the Netherlands and radiological risks. National Institute for Public Health and the Environment (RIVM) report 610053003, March 1996, Bilthoven (1996).
[18] NORM I, Proceedings of the International Symposium on Radiological Problems with Natural Radioactivity in the Non-Nuclear Industry (NORM I), Amsterdam, September 8–10, 1997, Brussels (1997).
[19] MARTIN, A., MEAD, S., WADE, B.O., Materials containing natural radionuclides in enhanced concentrations. European Commission, Report EUR 17625, EU, Brussels (1997).
[20] VAN WEERS, A.W., STOKMAN-GODSCHALK, A., Radiation protection, regulatory and waste disposal aspects of the application of mineral insulation wool with enhanced natural radioactivity, Proceedings of the Third International Symposium on the Treatment of Naturally Occurring Radioactive Materials (NORM III), Brussels, September 17–21, Brussels (2001).

REGULATORY AND MANAGEMENT APPROACH FOR TENORM IN NIGERIA

I. ISA FUNTUA
Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria

Abstract

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) has for a long time been recognized from two main sectors of the Nigerian economy, the petroleum and mining industries. The petroleum industry is large and has been active for over 40 years. There are proven reserves of over 30 billion barrels and a daily production of 2 million barrels each with about 1000 standard cubic feet (scf) of associated gas. The mining industry has been dominated by tin mining and processing for over six decades and these have generated extensive mine tailings that are rich in zircon, monazite, ilmenite and thorite which are highly enriched in thorium and uranium.

There had been no radiation protection and safety enforcement in Nigeria until the establishment of the Nigerian Nuclear Regulatory Authority (NNRA) in 2001. The NNRA has now drafted a regulation for the management of TENORM in the country in collaboration with relevant government agencies in charge of minerals and environment.

The regulations are to apply to any person who generates, possesses, uses, transfers or disposes of TENORM. It exempts materials containing or contaminated at concentrations less than 185 Bq/kg of ^{226}Ra or ^{228}Ra. The regulations provide for a general and specific licence and persons subject to a licence under these regulations are to comply with radiation protection standards set out in the Nigeria Basic Ionizing Radiation Regulations 2003.

1. INTRODUCTION

TENORM here means naturally occurring materials not regulated under the Radioactive Waste Management Regulations by the Nigerian Nuclear Regulatory Authority (NNRA) whose radionuclide concentrations have been increased by or as a result of human practices. In Nigeria TENORM is associated mainly with mining and processing of tin and columbite and in the exploration and production of oil and gas. TENORM management has been recognized as a major environmental problem for several decades in the mining and processing of tin and columbite because it is associated with zircon, monazite, thorite and ilmnite minerals that have high concentrations of thorium (up to 4 wt%) and uranium (up to 0.2%). The exploitation and processing activities has generated several tonnes of tailings rich in these minerals that are left haphazardly in the area. Recently the oil and gas industry has attracted attention with regard to TENORM. The industry has an oil reserve of over 30 billion barrels and a daily production of over 2 million barrels per day and about 1000 standard cubic feet (scf) of associated gas with each barrel of oil. The activities generate enormous amounts of waste in form of produced water, sludge and scales. Presently there are no regulations to monitor the TENORM generated from the mining and the oil and gas industry.

The Federal Government of Nigeria enacted the Nuclear Safety and Radiation Act 19 of 1995, which lead to the establishment of the Nigerian Nuclear Regulatory Authority (NNRA) in 2001. The NNRA has the responsibility for nuclear safety and radiological protection regulation in the country and within this short period has been very active in bringing regulations to govern practices that began several decades before its existence. This year the NNRA set up a Technical Advisory Committee for the Development of Radioactive Waste

Management Policy and Regulations for Nigeria with the main task of drafting National Radioactive Waste Policy and Radioactive Waste Management Regulations. The Committee drafted two regulations, one for Radioactive Waste Management and the other for TENORM. This is because of the well accepted view that the former represent typically small volume, high specific activity sources which include items such as sealed sources, while the latter represent typically very large volume, low specific activity sources which have been created by the processing or technological enhancement of materials originally found in nature with small concentrations of naturally occurring radioactive isotopes.

2. THE DRAFT TENORM REGULATIONS

The objective of the regulations is to establish radiation protection standards for the generation, possession, use, transfer and disposal of TENORM in order to ensure the protection of human health and the environment from the hazards associated with TENORM in Nigeria, at present and in future.

The scope of the regulations apply to any person who generates, possesses, uses, transfers or disposes of TENORM; the regulations address the introduction of TENORM into products in which neither the TENORM nor the radiation emitted from the TENORM is considered to be beneficial to the products; the manufacture and distribution of products containing TENORM in which the TENORM and/or its emitted radiation are considered to be a beneficial attribute are licensed.

The regulations do not apply to radionuclides defined as a source under the Nuclear Safety and Radiation Protection Act of 1995 [1]. It is understood that radioactive waste in any concentration regulated by the Nigerian Nuclear Regulatory Authority is not subject to this rule.

Exemptions are provided for persons who generate, receive, own, possess, use, process, transfer, distribute, and dispose of TENORM from the requirements of these regulations if the materials contain or are contaminated at concentrations less than 185 Bq/kg of ^{226}Ra or ^{228}Ra. Purposeful dilution to render TENORM exempt shall not be allowed and persons who receive products or materials containing TENORM distributed in accordance with a specific licence issued by the Authority pursuant to these regulations are exempt from these regulations with regard to those products or materials.

The 'Standards for Radiation Protection' for TENORM set in the regulations are:

(a) No person licensed under these regulations shall conduct operations, use or transfer TENORM in a manner such that a member of the public will receive an annual Effective Dose in excess of 1 mSv/a from all licensed sources including TENORM;

(b) Persons subject to a licence under these regulations shall comply with radiation protection standards set out in Nigeria Basic Ionizing Radiation Regulations 2003 [4];

(c) Doses from indoor radon and its progeny shall not be included in Effective Dose calculations;

(d) Use, transfer or disposal of TENORM shall be done in such a way as to prevent accumulation of radon in residential structures, schools and other public buildings in concentrations exceeding 0.15 Bq/l; and

(e) No person shall dispose of or release TENORM for unrestricted use in such a manner that the reasonably maximally exposed individual will receive an annual Effective Dose in excess of 0.25 mSv/a excluding natural background.

The provision for **'**Protection of Workers During Operations' is that each person subject to a specific licence under this regulation shall conduct operations in compliance with the standards for radiation protection set out in Nigeria Basic Ionizing Radiation Regulations 2003 [4] except for release of radioactivity in effluents, which shall be governed by the other relevant regulations, and disposal, which shall be governed by these regulations.

For 'Release for Unrestricted Use'**,** each person subject to a licence under these regulations shall ensure that facilities and equipment contaminated with TENORM in excess of the levels set forth in Table I below shall not be transferred or released for unrestricted use; or shall be evaluated prior to release for unrestricted use to ensure that the levels in Table I are not exceeded.

TABLE I. ACCEPTABLE SURFACE CONTAMINATION LEVELS FOR TENORM

	AVERAGE	MAXIMUM	REMOVABLE
Alpha	80 Bq/100 cm^2	250 Bq /100 cm^2	16 Bq /100 cm^2
Beta/Gamma	80 Bq/100 cm^2	250 Bq /100 cm^2	16 Bq /100 cm^2

For the 'Management and Transfer of Waste for Disposal' the provisions are as follows:

(a) Each person subject to a licence under this regulation shall manage and dispose of wastes containing TENORM in accordance with Nigeria Radioactive Waste Management Regulations and other applicable requirements of the Ministry of Environment for disposal of such wastes: by transfer of the wastes for disposal to a disposal facility licensed by the Authority; or in accordance with alternate methods authorized by the Authority upon application or upon the Authority's initiative, and consistent with these Regulations;

(b) Equipment contaminated with TENORM in excess of levels specified in Table I, which is to be disposed of as waste shall be disposed of: so as to prevent any reintroduction into commerce or unrestricted use; and within disposal areas specifically designed to meet the criteria of these Regulations;

(c) Transfers of waste containing TENORM for disposal shall be made only to a person specifically authorized by the Authority to receive such waste;

(d) Records of disposal, including manifests, shall be maintained pursuant to the provisions of these regulations; and

(e) Disposal practices and/or sites shall be subject to institutional controls as appropriate and determined by the Authority in accordance with these regulations.

Subject to some requirements of these Regulations a 'General Licence' shall be issued upon application to generate, possess, own, use, transfer and dispose of TENORM without regard to quantity. This general licence shall not authorize the manufacturing or distribution of products containing TENORM in concentrations greater than those specified in these Regulations nor the receipt and disposal of wastes from other persons.

A 'Specific Licence' is required to manufacture and/or distribute any material or product, deliberate decontamination activities and disposal of wastes from other persons unless otherwise exempted under the provisions of these Regulations or licensed under the provisions of Nigeria Radioactive Waste Management Regulations.

3. ISSUES ARISING FROM THE REGULATIONS

The regulation of TENORM is recent in most countries and the Nigerian draft is drawn from existing drafts and deliberations taking place in the United States of America and the European Union. It is good that Nigeria is participating at this time and would not need to catch up later. There would obviously be points of disagreement from the different stakeholders and the members of the public in the implementation of these regulations. The approach recommended is that the NNRA should initiate actions of presenting the draft documents to public and other stakeholders through workshops and seminars for comments, inputs and feedback.

There is an obvious need for an implementation guidance document for most of the provisions in the draft regulations. On the exemption value of 185 Bq/kg for example, there is the need to set screening levels based upon gamma survey results and these screening levels can be used to exempt various materials based upon evaluation of the results indicating the dose levels from the exemptions as fraction of the standard for radiation protection. The implementation guidance should also cover acceptable disposal methods for unique TENORM materials with the approval based on evaluation of the disposal options.

REFERENCES

[1] FEDERAL GOVERNMENT OF NIGERIA, Act No. 19 Nuclear Safety and Radiation Protection. Official Gazette of the Federal Republic of Nigeria, vol. 82, A547-A569, Abuja (1995).

[2] Part N, Regulating and Licensing of TE-NORM (February 1997 Draft), Abuja (1997).

[3] Nigeria TE-NORM Regulations (Draft), NNRA, Abuja (2004).

[4] Nigeria Basic Ionizing Radiation Regulations. Official Gazette of the Federal Republic of Nigeria, vol. 90, B165-B247, Abuja (2003).

[5] FUNTUA, I. I., NORM Monitoring Regulation for the Petroleum Industry, Abuja (2001).

[6] ELEGBA, S. B., Status of NORM in Nigeria. Presentation at IAEA Technical Meeting on Regulatory Approaches for the Control of Environmental Residues containing Naturally Occurring Radioactive Material (NORM), IAEA, Vienna, 23rd – 27th September 2002.

[7] Report of the Technical Advisory Committee for the Development of Radioactive Waste Management Policy and Regulations for Nigeria, NNRA, Abuja (2004).

REGULATORY AND MANAGEMENT APPROACHES FOR THE CONTROL OF ENVIRONMENTAL RESIDUE CONTAINING NATURALLY OCCURRING RADIOACTIVE MATERIAL, A SOUTH AFRICAN EXPERIENCE

S.A TSELA, Z. ZITUTA
The National Nuclear Regulator, Centurion, South Africa

Abstract

Without the discovery of the Witwatersrand Goldfields confined within the Witwatersrand Super group rocks, virtually no uranium apart from that produced at the Phalaborwa Mining Company (PMC) mine at Phalaborwa would have been mined in South Africa. The production of gold and uranium are inextricably linked in the Witwatersrand as the two elements occur together in the reefs of the Witwatersrand goldfields. This factor as well as the richness and extent of the gold deposits and the type of mining utilized to extract the gold bearing reef have a number of implications regarding the radiological hazards arising from the presence of uranium and the controls of such hazards in South African Gold mines and other mining and milling industries.

For radiological protection, mining and milling processes can be grouped into two main categories, namely uranium (and thorium) mines and non-uranium (and thorium) mines. The non-uranium mines, although not producing uranium as a main product may have elevated levels of uranium or thorium associated with the minerals that are mined as the main product. Currently the mining industry in South Africa is an example of the non-uranium mines.

This paper summarizes the regulatory and management approaches that have been implemented over the years in South Africa for the control of environmental residue containing Naturally Occurring Radioactive Material. The paper also outlines some challenges South Africa has experienced in this area and thus brings to the fore the need for the development of international requirements for NORM waste safety and environmental issues. Key issues are regulatory approach, dose, public perception, waste disposal and impacts on industry.

1. INTRODUCTION AND BACKGROUND

Naturally occurring radionuclides are present in most materials, such as ores, tiles, fertilizers, etc. In some materials the levels of naturally occurring radionuclides are significantly high to the extent that regulatory control is required for radiation protection purposes. However, in other materials the levels of naturally occurring radionuclides are very low, such that regulatory control is not necessary. Regulation of NORM presents a range of new challenges for both regulators and operators. South African National Nuclear Regulator and its operators are no exception to this.

2. REGULATORY AND MANAGEMENT APPROACHES

2.1. Nuclear authorization approach

The National Nuclear Regulator started regulating NORM facilities as early as 1993. Initially these facilities were authorized by way of a Nuclear Licence. Then seeing that radiological hazards arising from these facilities are different from those from Nuclear Facilities (such as Nuclear Power Reactors, Nuclear Technology Facilities, Nuclear Waste Disposal Sites and Nuclear Research Reactors) it was realized that Certificate of Registration is the best form of

Nuclear Authorization to be issued to all NORM facilities. To date all NORM facilities are operating under a Certificate of Registration. All Certificates of Registration are issued with facility specific type of conditions of authorization and operational limitations.

The NNR has adopted a prospective type of nuclear authorization but where necessary retrospective authorization is considered. An application pack with the following information is required from applicants:

- Application form;
- Certificate of incorporation;
- Scope of authorization (maps and GPS coordinates);
- Safety assessments for workers and the public;
- Operational radiation protection programme for workers and the public;
- Radioactive waste management programme;
- Transportation procedure;
- Physical security;
- Occurrence reporting procedure; and
- Quality management programme.

Deviations from the above requirements are accommodated provided proper justification has been provided. The basis for granting or issuing a nuclear authorization is always based on the following:

- That material to be handled is above 0.2Bq/g or 1000Bq;
- Application package information is complete and adequate;

In cases where a Certificate of Registration has been issued inspections are conducted at specific frequencies to verify compliance with conditions of nuclear authorization.

To clear or remove material or sites from regulatory control 0.2Bq/g is used where background is below 0.2Bq/g. Otherwise a background reference site is used. In case of surface contamination 0.04Bq/cm^2 for alpha and 0.4Bq/cm^2 for beta are used as clearance levels. Appendices 1, 2 and 3 present flow diagrams for clearance, exclusion and exemption criteria.

2.2. Scope of NNR nuclear authorization

The National Nuclear Regulator is currently regulating the following NORM facilities:

- 51 mining and mineral processing (gold, copper, mineral sands and uranium);
- Two service providers for cleanup of residue contaminated with NORM;

- 16 scrap processors
- Two scrap smelters
- 10 small users (laboratories); and
- Four fertilizer manufacturers.

2.3. Legal framework

The National Nuclear Regulator Act (NNRA) promulgated in 2000 forms a legal basis for regulating facilities listed in section 2.2 above. Before 2000, the Nuclear Energy Act was legally enforceable in this regard. Safety Standards and Regulatory Practices have been drafted and are now under discussion with interested and affected parties. After this process these standards will be applied to all facilities currently regulated by the NNR. Requirements documents and guideline documents are also used to enforce compliance with the NNR requirements. There are other forms of legislation that NORM users must comply with and these include:

- National Water Act from Department of Water Affairs and Forestry;
- Minerals Act from Department of Minerals and Energy;
- National Environmental Management Act from Department of Environmental Affairs and Tourism

Fig. 1 shows a hierarchy of NNR regulatory documents:

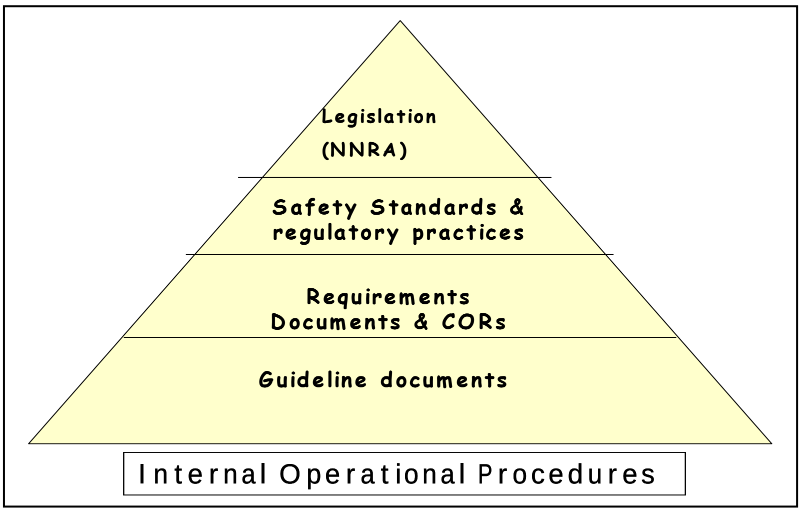

FIG. 1. Hierarchy of regulatory documents.

3. REGULATORY CHALLENGES

3.1. Contaminated sites

Problem

Through the lack of proper regulatory control of the NORM industry before 1993, vast areas of land are today contaminated with NORM residue. To date about 45 sites have been discovered and are currently being cleaned-up. Of the 45 sites, three are contaminated with uranium ore and the rest are contaminated with radioactive scale from scrap from gold mines. Because these sites are so big (0.5ha to 25ha), a survey is expensive to conduct. The availability of only one service provider in the country for sample analysis is also posing additional regulatory problems. Lack of owners for some of these sites is also a problem.

Approach to the problem

The mining industry has made funds available to cleanup these sites. Ownerless ones are being taken care of by government. So far 18 of the 45 sites have been cleaned up already.

3.2. Public safety assessment methodology

Problem

Currently safety assessments are done per authorized facility. However, the fact that similar critical groups are exposed to multiple sources that are not necessarily from the same facility present uncertainty with respect to estimated doses. The fact that background was not determined before most of the mining facilities were put in place presents additional uncertainties. Consumption rates default values currently in use are questionable to operators as they result into over-estimation of doses for certain pathways.

Approach to the problem

Apart from site specific safety assessment, regional safety assessments are being conducted by the NNR using results from various facility safety assessments. Local consumption patterns are used where possible. In addition to this, the National Background Radiation Survey has been conducted to help eliminate the extent uncertainty when performing dose calculation.

3.3. Environmental monitoring

Problem

Determination of proper radon monitoring points is still a point of contention. Some operators prefer to monitor at source and then assume that that is the amount of radon to the public. Some prefer to measure at the receptor (e.g. houses). In both cases there is a strong argument for and against any of the above-mentioned options. Determination of background in most mining areas is a problem because most of the region is or was used for mining activities before and as such it is contaminated.

With respect to dust monitoring, dust monitors are expensive, and therefore it is not possible to cover as many areas as possible. Where they are deployed, members of the public are unfortunately constantly illegally removing them. The involvement of more than one regulatory body in dust monitoring also complicates the issue. In most mining areas members of the public are now residing at about 500m away from the tailings dams. For the regulator or the operator to remove such people, data to demonstrate the level of hazards in these areas is necessary to convince developers and the Department of Local Government and Housing.

Approach to the problem

In response to the above-mentioned problems conservative types of modelling are used to control these two exposure pathways.

3.4. Increase of radioactivity on sediments due to effluent release

Problem

A number of studies conducted in various catchments in the country indicate that there might be an increase in activity concentration in sediments in surface waters. This is taking place even though the activity levels in wastewater being discharged into the main stream are low enough not to warrant regulatory restrictions. High activity concentration in sediments is of higher concern in dams used for recreation purposes and in beaches. The question now is whether to set more stringent controls on discharges or not.

Approach to the problem

A MEDUSA technology is being investigated to see if it can be used to quantify the magnitude of radioactivity in sediments. Depending on the outcome of this investigation, specific discharge limits will be introduced to all affected operators.

3.5. Illegal mining

Problem

As already mentioned above, gold mines in South Africa were previously formally not regulated. During that time some mines used scrap and tailings residue to backfill sinkholes. Most of these sinkholes are in areas that are outside the scope of regulation. Illegal mining is currently taking place in these areas for scrap and gold with no Radiation Protection. This is an issue for the regulator as it is its mission to protect people and the environment.

Approach to the problem

Because the major risk in the mining of sinkholes is not radiation, the Mine Health and Safety Inspectorate of Department of Minerals and Energy is playing a leading role to eliminate or formalize the practice of illegal mining. Control is also being strengthened at source to ensure that management of mine waste does not encourage illegal mining.

3.6. Waste management

Problem

Most mines are approaching closure. At the moment no option is available for final disposal of Category III waste. There is also no decision on the fate of tailings dams at mine closure. This has a negative impact on the review process of Mine Closure Plans. Currently there are about 136 tailings dams and 161 waste rock piles. The average area covered by a tailings dam ranges from 1 ha to about 100ha. The biggest tailings dam is about 800ha.

Approach to the problem

A couple of management options, such as tailings dams and gypsum dams, have been approved by the regulator. Dilute and store and dilute and disperse are other waste management option that have been approved by the regulator. A Draft National Radioactive Management Strategy/Policy has been prepared to cover all forms of radioactive waste. With the implementation of this policy most of the above-mentioned waste management constraints will be addressed.

4. RECOMMENDATIONS AND CONCLUDING REMARKS

Technical documentation on the management of NORM residue in the environment must be developed to help countries cope with the problems related to the regulation of NORM. In such an exercise, involvement of countries that have gone through these challenges is recommended. An agreement must be reached as to how far regulations must be applied to NORM products. A common assessment methodology for quantifying public exposures in different countries must be developed. Information exchange amongst countries must be encouraged.

APPENDIX 1:

CLEARANCE CRITERIA

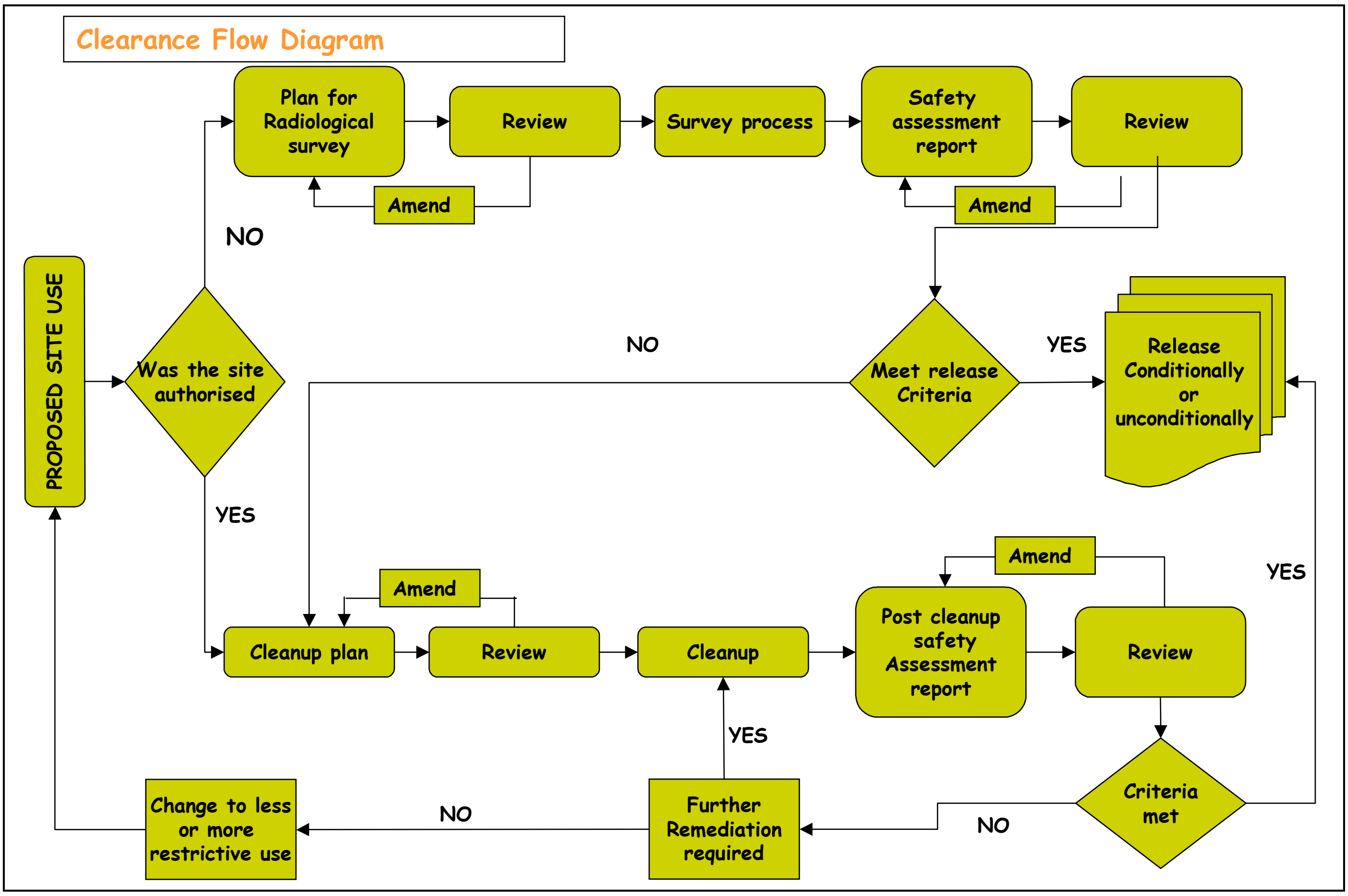

Fig.1. Flow chart showing application of clearance criteria.

APPENDIX 2:

EXCLUSION CRITERIA

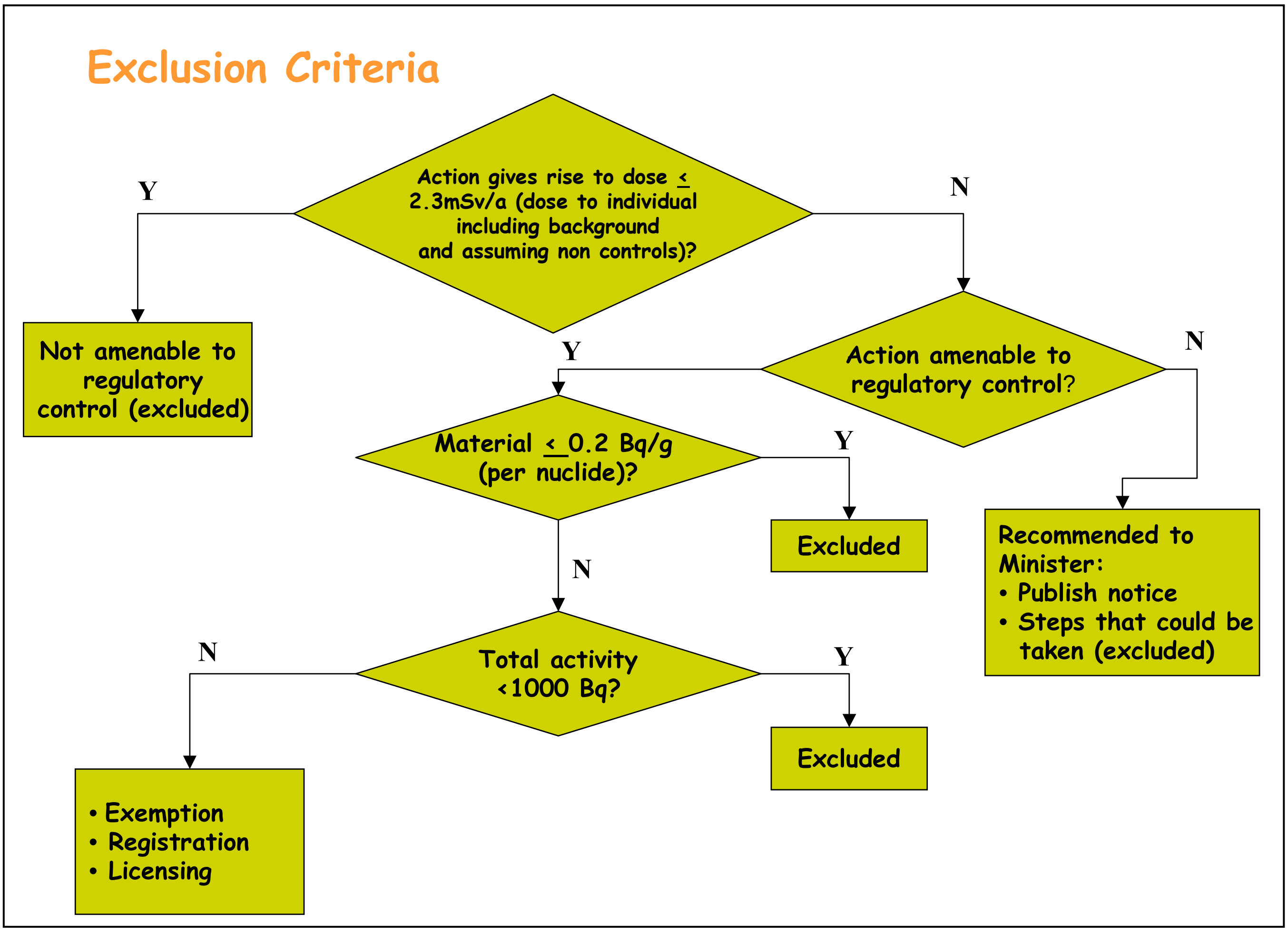

FIG.1. Flow chart showing application of exclusion criteria.

APPENDIX 3:

EXEMPTION CRITERIA

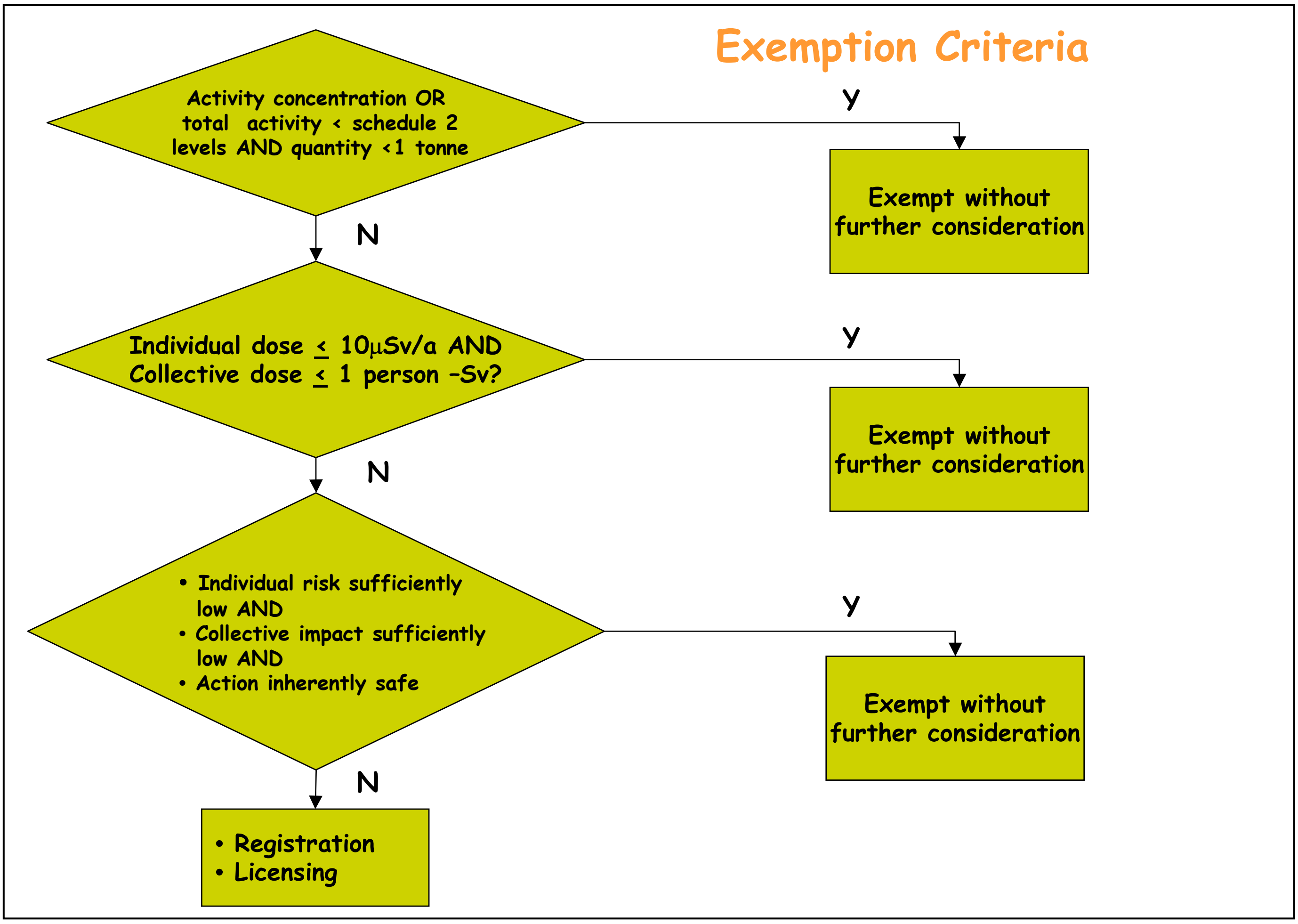

FIG. 1. Flow Chart showing application of exemption criteria.

PROPOSAL OF THE SWEDISH COMMITTEE ON MANAGEMENT OF NON-NUCLEAR RADIOACTIVE WASTE (IKA) AND THE IMPLICATIONS FOR THE MANAGEMENT AND STORAGE OF TENORM AND NORM WASTE

J-C. LINDHÉ, L. MJÖNES, N. HAGBERG, A-L. SÖDERMAN, G. ÅKERBLOM
Swedish Radiation Protection Authority, Stockholm, Sweden

Abstract

The Swedish Government Committee on Management of Non-Nuclear Radioactive Waste (IKA) had the commitment to propose regulations regarding NORM waste to be included in the Swedish Radiation Protection Law and the Radiation Protection Ordinance. The Committee delivered its proposals to the Government by 1st December 2003.

The production, handling and storage of materials classified as TENORM and NORM has earlier not been subject to legal regulations, but is now to be included in the Radiation Protection Law and Ordinance. The items to be included in the new regulations are listed.

It is proposed that that the user of raw material containing naturally occurring radioactive substances shall be fully responsible for disposal of the waste. The responsibility shall include a fee to a new Government fund to cover the total costs for management and future storage of the waste. This fee is to be paid by the producer of the waste material.

In case of legacy waste (with no present owner) the fund may be used to cover the cost. This might also be the case if disposal costs are unreasonably high for a private person. It is proposed that areas of legacy radioactive waste from old abandoned mines are to be regarded as contaminated sites and thus entitled to the same Government funds that are used for restoring land contaminated by chemical substances.

The Swedish Government Committee on Management of Non-Nuclear Radioactive Waste (IKA) also has given proposals for future storage of other kinds of non-nuclear material, for example highly radioactive sources used in industry, radioactive hospital waste and smoke detectors.

1. INTRODUCTION

The following text is mainly based on a summary of the report SOU 2003:122 from the Swedish Government Committee on Management of Non-Nuclear Radioactive Waste (IKA) submitted to the Swedish Government in December 2003 [1]. In our text we have concentrated on the Committee's proposals for TENORM and NORM. At present most of TENORM and NORM materials are not subject to regulations as their content of radioactive elements are lower than the Swedish exemption levels. As an example, the exemption level for uranium-238 in equilibrium with its decay nuclides is 10 kBq/kg. The IKA-investigation has also given proposals for future storage of other kinds of non-nuclear material, for example highly radioactive sources used in industry, radioactive hospital waste and smoke detectors. An extensive summary of the investigation is given in Safe Management of Non-nuclear Radioactive Waste. Summary of the Swedish IKA-investigation SOU 2003:122. (Copyright ÆÉ by WM Symposia, Inc. All Rights Reserved. Reprinted with permission.) For the full summary see: www.sou-gov.se/ikautredningen/PDF/Summary_SOU-2003-122.pdf

2. DIRECTIVES

The Swedish Government on 23rd May 2002 decided to set up a non-standing committee on Non-nuclear Radioactive Waste. According to the directives of the Committee, the objective was to analyse and propose a national system for the handling and final disposal of non-nuclear radioactive waste. The system must involve a well functioning solution with regard to organization, the environment, finance and legislation. The Committee adopted the name the IKA Committee (IKA — a Swedish abbreviation for non-nuclear radioactive waste, i.e. radioactive waste unrelated to nuclear technology). Representatives from the Ministry of the Environment, the Swedish National Environmental Protection Authority, the Swedish Radiation Protection Authority (SSI), the Swedish Nuclear Power Inspectorate, the Swedish Rescue Services Agency assisted the committee. This group also included representatives from the Confederation of Swedish Enterprise and the Swedish Nuclear Fuel and Waste Management Company (SKB), owned by the nuclear power industry. The SKB now has the task of taking care of Sweden's spent nuclear fuel and the radioactive waste from the nuclear industry.

2.1. Comprehensive aims and principal starting points

A natural starting point is the environmental objective of a Safe Radiation Environment ('Säker strålmiljö', bill 2000/01:130 Swedish environmental aims – objectives and strategy measures) [2] that, among other things, states that:

By 2010, the content in the environment of radioactive substances that are released by every enterprise must be so low that public health and biological diversity are protected. The additional individual dosage to the public must fall below 0.01 mSv/person/year from each separate enterprise.

To this, the government added a clarification that:

- Radiation doses are to be kept within bounds As Low As Reasonably Achievable (ALARA); and

- The highest total annual effective radiation dose, that a member of the public may be exposed to from an enterprise involving radiation, must not exceed 1 millisievert (mSv) per person during a one-year period.

In many cases, these aims and principals establish the absolute dose limits for people and the environment. The International Atomic Energy Agency (IAEA) "Joint convention on the safety of spent fuel management and on the safety of radioactive waste management" establishes the fundamental principal that the handling of radioactive waste must not be put onto the shoulders of future generations.

When it comes to a system for the handling and final disposal of non-nuclear radioactive waste, the principal starting points for being able to meet the above stated aims for overall protection against radiation, as well as the aims and starting points for environmentally adapted waste handling, can be summarized as follows:

With regard to *waste*, the following should apply:

- All radioactive waste, except for that classified as cleared, should be collected and taken care of ('100 % requirement');

- The amount of waste should be minimized and any danger due to waste is to be successively reduced;

- The ALARA principle for radiation doses must be put into practice;

- The handling of non-nuclear radioactive waste must fulfil the demands for protection against radiation, in accordance with the overall radiation protection aim and norms for:

  (a) The workers handling the waste;

  (b) The public and the environment;

  (c) Minimizing the discharges and risks for accidents;

- Properties other than the ionizing radiation of waste must be taken into consideration, e.g. biological and chemical properties.

The *national waste system* should fulfil the following demands:

- The waste system must be organizationally, environmentally, financially and legally well functioning;

- A defined producer responsibility must apply, as far as possible;

- The handling of radioactive waste must not impose undue burdens on future generations.

2.2. Product waste, industrial waste and other waste

The Committee divides non-nuclear radioactive waste into three main categories:

Product waste. This includes household products as well as products used in research, industry and hospitals, etc. For this category it is easy to identify a producer who imports or manufactures the product and puts it on the Swedish market. Such activities need a licence from the Swedish Radiation Protection Authority (SSI) according to the Swedish Radiation Protection Ordinance [3].

In this category are included both products that require authorization for handling in all aspects, e.g. strong sealed radiation sources, and mass-consumption items, such as single-unit smoke detectors (with a battery), where only the manufacturer/importer is required to have authorization for handling.

Industrial waste. Radioactive substances appear naturally in nature. These substances can become concentrated in certain industrial operations that handle large amounts of naturally occurring substances. This type of waste includes TENORM, NORM and biofuel ashes from combustion plants. Most of these processes are licensed anyway under the Environmental Code and funding for the management of the radioactive waste emanating from such practices can be settled in the licensing procedure along with specific conditions on the generation and handling of the waste.

Other waste. This concerns waste that is neither Product waste nor Industrial waste. It can include certain production waste, older waste or abandoned waste without any legally responsible owner. It also includes waste with no known owner, e.g. orphan sources and radioactive waste discovered in scrap metal. *Other waste* is a minor contributor of waste compared to the other two main groups and the necessary surplus of the funding system may well cover the costs also for the management of this waste.

3. PROPOSALS FROM THE COMMITTEE

3.1. Producer responsibility

The Committee proposes that:

- All producers of products with radioactive substances as components or products in the form of radiation sources must be imposed with a producer responsibility for the waste that arises when the product or the radioactive component is discarded or scrapped (Product Waste). By producer is meant anyone who produces, imports into the country or releases products on the market that give rise to radioactive waste. This responsibility must include an obligation for taking back the products after completion of use and for being in charge of the final handling of the waste.

- Producer responsibility should include a fee that would go to a special state fund for meeting the total costs of handling any arising radioactive waste, including final disposal if it is dealt with in Sweden.

- When it comes to waste to be taken back by a supplier for final disposal in the country of origin, a bank guarantee or the equivalent should be insisted on.

- The fee must meet a reasonable share of the total costs of the historic waste for which no financial producer responsibility was previously in force.

- A State fund is established for collecting and administering the fees that producers pay for the handling of non-nuclear radioactive waste (The IKA Fund), together with making payments under the authorization of the Swedish Radiation Protection Authority (SSI).

- The Fund should be tied in with the existing Nuclear Waste Fund and share the same administrative body.

- SSI should be given a wider role when it comes to producer responsibility:

  — For checking authorization and keeping a register of producers;

  — For establishing and debiting fees;

  — For receiving compensation demands and approving disbursements;

  — For issuing instructions concerning handling and financing of non-nuclear radioactive waste;

  — For checking and monitoring the waste handling system.

- A special advisory committee with representatives from the side of the producers and authorities should be attached to SSI for following up and scrutinizing SSI activities within this area. The committee should also be able to make decisions on recommendations concerning the activities.

- The new system of producer responsibility for non-nuclear radioactive waste should come into effect on 13th August 2005, concurrently with the new regulations that intend to implement the EU Directive 2002/96/EG [4], concerning waste from electrical or electronic products.

3.2. Industrial waste

The Committee proposes that:

- Radioactive Industrial Waste, i.e. radioactive waste that arises through enrichment of naturally occurring radioactivity or through the handling of biomass containing fall-out from nuclear weaponry tests or nuclear technology accidents, e.g. combustion of bio fuels, must be handled according to the Swedish Environmental Code [5] regulations, regarding ecologically harmful activities.

- Operations that can be thought of as giving rise to radioactive Industrial Waste should, in the first place, be tested for authorization, according to the Swedish Environmental Code, and this must be preceded by a description of the environmental consequences regarding radiation risks and the genesis of Industrial Waste.

- Operations that give rise to Industrial Waste but which have not been tested for authorization, according to the Environmental Code, must be regulated through the application of the Radiation Protection Legislation.

- It must be possible for permits for ecologically harmful operations to include conditions about preventive measures that aim at avoiding or restricting radioactive waste arising, as well as conditions for how waste is to be managed and taken care of or to include delegation to the supervisory authority to issue further regulations about the management of the waste.

- In cases where the Environmental Court or a County Administrative Board issues conditions concerning the taking care of radioactive Industrial Waste that involves demands for financial security, an enterprising party should pay a fee to the IKA Fund to guarantee that the waste can be taken care of correctly on the discontinuation of the operations. This is to be regulated in the legislation concerning the setting up of the IKA Fund.

- The radiation protection legislation is to be altered, so that Industrial Waste is covered by the provisions of the legislation, concerning responsibility for radioactive waste through the Radiation Protection Ordinance being made applicable to Industrial Waste.

SSI should:

— Where applicable, issue general instructions for the management and final disposal of certain Industrial Waste, with the support of the Radiation Protection Act [6], in accordance with the above mentioned amendments.

— Be granted the right to be able to request a reappraisal of operations that give rise to radioactive Industrial Waste, according to the Environmental Code, and to be identified as the supervisory authority in the Ordinance for supervision [7].

— Be given the mission of informing about problems with radioactive Industrial Waste in the respective trade journals and to publish general advice on the management of such waste.

— Confer with the Swedish National Environmental Protection Authority for being responsible for the supervisory and regulatory committee. SSI ought to be included in this committee.

3.3. Other waste

The Committee proposes that:

- Those liable for payment to the IKA Fund deposit a proportionate contribution to the Fund, in order to meet the costs for dealing with any other waste, where it is not possible to establish a legally responsible party for the waste.

- Within their present inventory program and yearly suggestions concerning measures to decontaminate contaminated land and deal with hazardous waste in old industrial plants, the County Administrative Boards should be given the mission to include radioactive waste and radioactive contaminated land. SSI should be given the mission to assist the County Administrative Boards and the Swedish National Environmental Protection Authority with information and expert knowledge in this work. The appropriation for decontaminating and dealing with hazardous waste should, where appropriate, also be available for measures to decontaminate the radioactive waste.

- Those activities operating with radiation that give rise to contaminated matter or induced radiation must be able to be charged with paying the fee for dealing with the waste to the IKA Fund.

3.4. Clearance

The Committee proposes that:

- SSI be given the opportunity to make decisions about general exceptions to the Radiation Protection Act [6], when this is well founded, from the point of view of radiation protection and when it concerns the demands for an effective management of non-nuclear radioactive waste; a so called *clearance*.

- Amendments are made to the Radiation Protection Ordinance [3] to achieve this goal.

3.5. Final disposal and the role of Swedish Nuclear Fuel and Waste Management Company (SKB) and Studsvik in the waste system

The Committee's proposal for final disposal:

At the earliest possible opportunity, the State should commence negotiations with Swedish Nuclear Fuel and Waste Management Company (SKB), regarding a general agreement for the final disposal of non-nuclear radioactive waste, based on the grounds that the Committee discussed with SKB during the investigation. These imply, among other things, that SKB undertakes the final disposal of all non-nuclear radioactive waste that requires such final repositories as in any of its existing or future plants and will do this for, principally, cost price. Furthermore they imply that SKB must be able to receive compensation also for actions taken for the adaptation of the storages and for the reappraisal of the licensing conditions for the repositories when necessary.

The Committee's assessment of Studsvik AB (Ltd.):

In the 1950s the main part of Swedish nuclear research was located at Studsvik, on the east coast 100 km south of Stockholm. Two research rectors were built, together with a waste handling system and an intermediate repository for low and medium radioactive waste. From the beginning, the enterprise at Studsvik was state owned but it is now privatized. As Studsvik AB is the only Swedish enterprise that handles non-nuclear waste, the company has a monopoly position on the market for services. This is now a problem as Studsvik AB has no obligation for taking care of radioactive waste and the cost for future storage of long-lived radioactive waste is not known. Thus Studsvik can refuse to handle and dispose of radioactive waste if the cost for storage is not covered or if it contains long lived nuclides, e.g. radium or thorium. Also the costs for handling and storage are so high that private persons or small enterprises cannot bear them.

However these problems will substantially decrease if the Committee's proposals for a national system for non-nuclear radioactive waste are realized. The grounds of Studsvik AB, and any other possible players on the market, for not handling certain kinds of radioactive waste, disappear in part or completely. The Committee therefore concludes that there is presently no need for any duty, regulated by law, to take care of non-nuclear radioactive waste. Nevertheless, the Government ought to closely follow the development of this issue.

4. DELIBERATIONS

4.1. Clearance

Today, SSI is unable to issue regulations on clearance (i.e. exceptions to the entire Radiation Protection Act application) except in individual cases.

However, there are good possibilities for introducing a more operative clearance system in Sweden, without waiving the basic radioactive protection demands or obstructing the environmental goal for a secure radioactive milieu from being reached, that stands in agreement with the EU regulatory framework. Further development work in SSI is needed, however, before an operative system for clearance can begin, which will meet the highest demands placed on radiation security. It is taken for granted that a change is made to the Radiation Protection Ordinance [3] that will permit general decisions about clearance from the Radiation Protection Act's application [6].

SSI has pointed out a list of problems with the current management of radioactive waste. One point concerns the case when an operator of an enterprise goes bankrupt or closes down operations. Waste from radioactive sources may then lack a legally responsible person, who can cover the costs for the management and possible final disposal of the waste. The same thing concerns orphan radiation sources that occur in nature or at waste service sites. A producer responsibility, that lays the responsibility for the waste management on the producer and not on the owner, has a great potential for being able to substantially reduce the number of cases where an owner could consider disposing of a hazardous radiation source illegally or in an inappropriate manner. The hazardousness of the radioactive waste and the need for being able to take care of all waste provides motivation for a producer responsibility. A suitably formulated producer responsibility makes it also possible to successively reduce the amounts of waste and diminish the hazardousness of the waste. Generally, there is a direct relationship between the amount of waste that a radioactive product gives rise to and the costs for dealing with the waste. Reduced activity in the product simplifies the management in all aspects, when it comes to taking care of the waste. Reduced activity and short-lived isotopes diminish the demands on final disposal and, therefore, make the waste management cheaper. Even when designing a product, producers have greater opportunities of taking these possibilities into account for making the products cheaper to deal with.

In the Committee's opinion, there is, therefore, motivation to develop a system of producer responsibility for radioactive products. Moreover, such a producer responsibility has to be added to the existing Radiation Protection Act regulatory framework.

A producer responsibility for radioactive Product Waste should partly include an obligation for the producer to be responsible for the collecting, management and final disposal of radioactive waste, and partly a liability to leave financial guarantees for the managing and final disposal of the waste. Producer responsibility should also include historic waste, like orphan radiation sources. In the Committee's opinion, the producer responsibility model is the system that best meets the demands made on non-nuclear radioactive waste, with regard to Product Waste. This also has the advantage of leaving considerable room for the market to formulate the systems that can provide for collecting, managing and final disposal, if necessary, in a cost effective manner.

4.2. Demands for financial solutions

A system with financial guarantees must be created for dealing with radioactive waste, so that needed resources can always be guaranteed. Due to the hazardousness of the waste, there is motivation for not allowing radioactive substances to become orphaned or to be illegally utilized for anti-social purposes. Even if companies go bankrupt or change the direction of their operations, the necessary resources must exist for taking care of the radioactive waste.

When it comes to non-nuclear radioactive waste, the demands have to be high. A financial system for non-nuclear radioactive waste ought to meet the following demands:

- Have the potential to result in a 100% safekeeping;
- Secure financing over a long period;
- Provide high and secure yields on established resources;
- Allow fees or appropriations that lead to reduced amounts of waste and diminished hazardousness in the waste;
- Must function well:
    - Organizationally;
    - Environmentally;
    - Financially; and
    - Legally.

The demands will be especially clear if one considers the case that, in most instances, radioactive waste must be stored, sealed in special rock shelters for many centuries. Suitably sealed storages do not presently exist and will not become a reality for another 30 years or so. The financial resources have to also be secured for long periods. The delay is so long that many companies might have left the market for various reasons, when the costs for final disposal arise.

Today, there exist four state funds for waste. They are the Nuclear Waste Fund, the Studsvik Fund, the Battery Fund and the Car-Wrecking Fund.

The Nuclear Waste Fund. The Nuclear Waste Fund is a state fund system, created in 1981 to ensure financing of radioactive waste from nuclear power stations. The financing is regulated by legislation (1992:1537) concerning the financing of future expenditure for spent nuclear fuel. The fund has a book value of SEK 29.4bn (approx. €3.2bn) and a market value of SEK 31.3bn (approx. €3.4bn).

The Studsvik Fund. Fund for financing existing waste from, among others, the closed combined power and heating nuclear plant in Ågesta, and the closed research reactor, R1, in Stockholm, and waste from the research reactors at Studsvik.

The Battery Fund. The battery Fund is a state funding system to ensure the taking care of environmentally hazardous batteries. The total balance for mercury batteries is SEK 68·4m (approx. €7.4m), for lead batteries SEK 262m (approx. €28.5m) and for nickel cadmium batteries SEK 243m (approx. €26.4m). The total fund balance amounts to SEK 573m (approx. €62.3m).

Other financial solutions. As set out above, there are several alternative solutions for guaranteeing the financing of radioactive waste. Along with the state funds for covering the costs of waste, there are also examples of private solutions. These apply to, for example, electronic waste and, in part, mercury.

The Committee proposes a State Fund. On the basis of the discussion going on regarding the possibilities of meeting the demands placed on the financial mechanism for radioactive waste, a state fund is the Committee’s proposal for guaranteeing resources for managing radioactive Product Waste.

As will be seen from the Committee’s proposal concerning Industrial Waste and Other Waste, the proposed state fund solution could also be utilized for Industrial Waste as well as certain Other Wastes. When it comes to the administration of paid resources, the association of the IKA Fund with the Nuclear Waste Fund is the only realistic and efficient alternative.

4.3. Waste resulting from concentration of naturally occurring radioactivity

Industrial waste

Radioactive substances occur naturally in nature. One example is radium. They can be enriched and concentrated in certain industrial processes, which deal with large amounts of naturally occurring substances. This applies, for example, to water flows in pipes and contaminated oil. Industrial water is filtered in many contexts and these filters can concentrate radioactive substances that occur naturally. This even applies to heat exchangers and municipal drinking-water treatment works. Peat ash and ashes from combustion of bio fuels may contain significant amounts of radioactive substances. Ashes from bio fuels may contain cesium 137.

This waste, usually called NORM (Naturally Occurring Radioactive Material) or TENORM (Technically Enhanced NORM), has to be introduced into the waste-flow under the same criteria as for other radioactive waste. It occurs, in most of the cases, in activities that do not have activities involving radiation as a primary objective, i.e. that are not in operation with radiation, according to the definition in the Radiation Protection Act [6]. The enriched or concentrated radioactivity is an unwanted by-product, as is other types of waste or pollution from operations. Waste that occurs, in the manner described in enterprises that are not licensed to operate activities involving radiation, is called Industrial Waste.

The environmental code and radioactive industrial waste

According to the Environmental Code [5], environmentally hazardous operations are considered to be, among others, the use of land, buildings or installations in such a way that inconvenience may occur to the surroundings through ionizing or non-ionizing radiation, among other things. This makes it possible to assess such operations for authorization that give rise to inconvenience, due to radiation from radioactive waste, as an example. The Code also states that it can be forbidden to release or store solid waste or other solid substances, if this can lead to land, water areas or ground water being polluted without authorization.

Furthermore, according to the Environmental Code [5], all who operate activities must take the protective measures, observe the limitations or practice the precautionary measures necessary for protecting against damage or inconvenience to people's health or the environment. The Environmental Court or a County Administrative Board realizes a permit appraisal for environmentally hazardous operations. According to the Environmental Code, a judgement on a permit, where appropriate, contains decisions about the conditions necessary for the management of waste and recycling and re-utilization if the management, recycling or reutilization can give rise to inconvenience for the external environment. The permit appraisal organ can further commission the supervisory authority to issue detailed conditions for dealing with waste. It is, consequently, fully possible to assess radioactive Industrial Waste for authorization, according to the Environmental Code.

In the Environmental Code, there are regulations concerning Accounts of Environmental Consequences (MKB). These constitute an important component, when assessing Industrial Waste. SSI has to play a proactive role in informing about problems with radioactive Industrial Waste, aimed both at the permit assessing authorities and the supervisory authorities, as to the lines of business involved.

It must be the role of SSI to be able to issue general advice and instructions for Industrial Waste, operative supervision and supervisory guidance in those cases where, according to the Environmental Code, other organs are the supervisory authorities. This could be achieved by adding SSI in the Ordinance (1998:900) regarding supervision [7], according to the Environmental Code [5]. This implies that the authority would be included in the supervisory and regulatory council of the Swedish National Environmental Protection Authority.

SSI has suggested to the Committee how the definition of operations involving radiation, in the Radiation Protection Act [6], could be expanded to make it possible to issue general advice and instructions in those cases where Industrial Waste is not appraised, according to the Environmental Code. This would be achieved through an amendment to the Ordinance on supervision according to the Environmental Code.

The Environmental Code applies in parallel with the Radiation Protection Act. Those that operate activities with radiation are also liable, apart from the provisions in the Radiation Protection Act, to observe and put regulations of the Code into practice. If a conflict between the legislation should arise, i.e. a regulation in the Environmental Code should be inconsistent in relation to some regulation in the Radiation Protection Act, then the provisions in the Radiation Protection Act take precedence over the Environmental Code. According to the Environmental Code, the permit appraisal authority should pay attention to these relationships during the appraisal itself.

Connection to the financing system for product waste

With the aid of the Environmental Code regulations, it is possible to make demands on operators of activities to allocate resources for after-treatment, by taking care of arising waste. The easiest way of achieving this is for the permit appraisal authority, in the permit, to enlighten the operators of the activities that they are liable to pay a fee, according to legislation for the financing of non-nuclear radioactive waste. In this way, the IKA Fund could be a general instrument for the financing of radioactive waste that demands financial guarantees for being taken care of and/or for final disposal, if necessary.

4.4. Final repository capacity

At present in Sweden an underground repository for low and medium waste (SFR) exists at the Forsmark Nuclear Power Plant. The owner of this repository is SKB. A final underground repository for highly active and long-lived waste (SFL) is to be built within 30 to 40 years. At Studsvik non-nuclear radioactive waste can be temporarily stored. There is a rock shelter for 6000 m^3 of packaged waste, with a large available capacity. With the information available and with today’s know-how, the Committee estimates that this space will probably be sufficient for the whole period of 40 to 50 years until SFL is ready.

SKB and final disposal

Today, SKB has no direct obligation to accept non-nuclear radioactive waste, but SKB has itself expressed its ambition thus: “We take care of Sweden’s used nuclear fuel and radioactive waste so that the environment and people’s health are protected in the short and long term.” As a basis for this, SKB has undertaken to finally dispose of all non-nuclear radioactive waste that can be disposed of in a SKB final repository, under certain conditions. According to SKB, the principle would be cost price for final disposal. Resources from the IKA Fund could be requisitioned to cover the increasing general costs for the licensing or re-licensing that could be demanded, so that it will be possible to finally dispose certain substances and material that were not originally included in the planning.

As stated, the matter of final disposal should not be any great problem in the future, from the aspect of capacity. Non-nuclear radioactive waste volumes are significantly less than the volumes of nuclear waste, even if the isotope combination can vary. With the final repository that exists, SFR, and the planned final repository, SFL, it should be possible to finally dispose of all non-nuclear radioactive waste within the foreseeable future. Under certain circumstances, a commercially practicable alternative could be to use additional space in the planned rock shelter repository for mercury.

Forms for ensuring that Studsvik accepts radioactive waste

If the Committee's proposals are realized, Studsvik no longer needs to absorb risks when it comes to final disposal. Those responsible for producing waste or other parties can close their own agreements with SKB if the final disposal part and Studsvik's services can be purchased separately. With that, the Studsvik operations and offered services will be wholly independent and there will be well-defined sections in the waste management chain. The Committee expects that the market, with its prerequisites, will solve the problems for Studsvik in its present situation and the problem of Studsvik's monopoly position will mainly disappear. The new market situation could also open up for market participants other than Studsvik AB. This means that, even if it is possible to legislate for an injunction for handlers of waste to accept radioactive waste, then this solution should not be used in the situation that is expected to arise.

5. SURVEYS

5.1. Types of waste and waste-flows

Consumer items

Included in this category are smoke detectors and products, which are sold as night-seeing aids, in the form of telescopic sights, bearing compasses and bearing binoculars. A good deal of radioactive waste also comes from consumer items from former times, when it was permitted to use clocks with luminous faces and uranium compounds could be used to give a lustre to colors on ceramics and, sometimes, even on crockery and glass.

NORM – TENORM etc.

This type of waste mainly comes from industrial processes that use large volumes of naturally occurring radioactive substances (NORM*)*. These have, as a rule, been enriched through the processes. A technical term for this is TENORM. Residue waste, such as slag from mining operations, sand filters or the equivalent from water works etc. are, in certain cases, so enriched with natural radioactive substances with long half-lives, that the waste must be taken care of in a special manner.

Combustion of bio fuels and peat gives rise to ashes with increased contents of radioactive cesium, predominantly from fallout after the Chernobyl accident. About 100 000 tonnes of bio fuel ash from wood fuel and 30 000 tonnes of peat ash are produced annually.

Depleted uranium is a residue product that remains, when natural uranium is enriched to form nuclear fuel or nuclear weapons. It is only when the depleted uranium has to be taken care of as waste that it presents a radiation protection problem. By a rough estimate, there are a few dozen tonnes of it in Sweden. The biggest environmental hazard comes from the chemical toxicity of uranium.

Open and sealed radiation sources

Sealed radiation sources in industry are sometimes returned to the supplier when they are scrapped, but it is often the owners themselves who are responsible for the waste being taken care of within the country. Non-nuclear radioactive waste from hospitals, research and education often consist of *open* radiation sources, e.g. when the radioactive substance is found in the form of a liquid solution. At a rough estimate, Sweden generates a few dozen kilograms of waste from radioactive chemicals each year, which does not cause any great waste problem. Solid waste from these operations can be protective clothing, glass jars etc. with small amounts of radioactive substances. The suppliers take most of the sealed radiation sources back as a rule, in some kind of exchange system. For practical reasons, the scrapped sources are always sent abroad to the country they came from, in such cases. However, radiation sources from the medical care sector still occur which, after many years' usage, must be sent to Studsvik to be taken care of. Activities in research, hospitals and education are expected to continue at the present rate.

To sum up, of concerns here are one to two hundred strong to medium strength radiation sources from industry, hospitals, research and education that need to be finally disposed of in Sweden, every year.

Abandoned radiation sources lack known lawful owners, responsible for their scrapping. In today's circumstances, the one who finds such an orphan source becomes likewise its owner and, with that, according to the Radiation Protection Act [6], is responsible for taking care of it. It is important to build an efficient system for reducing risks from abandoned sources, since these can be the cause of grave consequences with financial damages and acute radiation injuries. The International Atomic Energy Agency (IAEA) in Vienna has also warned against terrorists using orphan radioactive waste to make terror bombs, the so-called *dirty bombs*. In Sweden, abandoned radiation sources are reported to SSI once or twice a year.

6. EXPECTED OUTCOME

The IKA-Committee's proposals are now handed over to the Government. After remittance the Government final proposal will probably be presented to the Parliament early in the year 2005. It is expected that the new regulations and agreements will be in force later in 2005.

REFERENCES

[1] SOU 2003:122, Radioaktivt avfall i säkra händer, Betänkande från utredningen om radioaktivt avfall från icke kärnteknisk verksamhet (IKA), Statens offentliga utredningar, Stockholm (2003).

[2] SWEDISH ENVIRONMENTAL PROTECTION AGENCY, Sweden's environmental objectives no. 6: A safe radiation environment, Stockholm (2004).

[3] SWEDISH GOVERNMENT, Swedish Radiation Protection Ordinance (1988:293) Stockholm (1998).

[4] EUROPEAN COMMISSION, Council Directive 2002/96/EG of 27 January 2003 on waste electrical and electronic equipment (WEEE), Official Journal L 37/24, 13.2.2003, EU, Brussels (2003).

[5] SWEDISH GOVERNMENT, Swedish Environmental Code (SFS1998:808), Stockholm (1998).

[6] SWEDISH GOVERNMENT, Swedish Radiation Protection Act (SFS 1988:220), Stockholm (1998).

[7] SWEDISH GOVERNMENT, Ordinance on supervision according to the Environmental Code (SFS 1998:900) Stockholm (1998).

[8] EUROPEAN COMMISSION, Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (HASS), Official Journal L 346/57, 31.12.2003, EU, Brussels (2003).

TENORM REGULATION IN THE UNITED STATES OF AMERICA

L.W. SETLOW
U.S. Environmental Protection Agency, Office of Radiation and Indoor Air,
Washington, D.C., United States of America

Abstract

TENORM wastes and consumer products are regulated in the United States by either Federal or State government agencies. There is no single, national law governing TENORM. Most agencies apply general radiation protection and waste disposal standards devised for all sources of radiation to TENORM. This is done to facilitate the protection of the public and occupational workers, identify appropriate types of waste disposal sites (cells), and decide upon guidance for cleanup of radioactively contaminated sites. Generation of TENORM by some industries, however, is controlled by specially designed Federal or State regulations (e.g. phosphate, oil and gas, elemental phosphorous, and uranium mining).

1. RADIATION PROTECTION LAW IN THE UNITED STATES

1.1. The Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC)

TENORM as used in this paper refers to materials containing naturally occurring radionuclides whose radioactivity has been concentrated or exposed to the accessible environment as a result of human activities, such as manufacturing, mineral extraction or water processing. The Appendix provides a tabular summary of U.S. governmental and advisory body guidance on TENORM.

U.S. controls or licensing of sources of radiation differ from many other countries. Although any of the TENORM radionuclides, which include uranium, thorium, radium, and potassium, and their decay products, could be present in a TENORM waste or product, the Atomic Energy Act of 1954 as amended assigns health, safety, and licensing responsibility specifically for just uranium and thorium (termed 'source material') to what is now the U.S. Nuclear Regulatory Commission (NRC). However, NRC does not license individuals or companies which utilize uranium or thorium in concentrations below 500 parts per million. In fact, mining operations are not licensed by that agency with the exception of *in-situ* uranium leaching facilities. The NRC also licenses radioactive waste disposal facilities. Under that agency's authorities, it can delegate its statutory authority to States whose regulations are compatible with NRC's. Because of this special situation, and judicial decisions affirming NRC authority over uranium and thorium, regulation of TENORM exposures, waste handling, and disposal is complicated if a site contains a mixture of uranium, radium, and other radionuclides.

More than a dozen major laws form the legal basis for the programs of the Environmental Protection Agency (EPA). That agency's authority to develop radiation protection standards and to regulate radioactive materials including TENORM is derived from a number of those Federal laws, plus Executive (Presidential) Orders. EPA is currently working with a number of other Federal agencies to update U.S. guidance for radiation protection of members of the general public

EPA also has responsibilities for radiation emitted into what are termed environmental media, either air, water, or land (in this case, as wastes). Under the Clean Air Act, EPA regulates radon and radioisotope emissions into the air. Regulations promulgated by the agency specifically target emissions from underground uranium mines, Department of Energy facilities, elemental phosphorous plants, and radon from phosphogypsum stacks. Required by laws specific for radon abatement, EPA has also developed guidance for control of radon in private houses residential housing, schools, and most recently for drinking water treatment and wastewater (sewage) treatment facilities.

The Clean Water Act and Safe Drinking Water Act give EPA the authority to establish water quality standards, regulate the discharge of pollutants into waters of the United States, and set standards for drinking water. In the case of drinking water, regulatory standards have been set for uranium, radium-226 and radium-228, and address combined alpha, beta and photon emitters. Draft proposed limits have also been issued for radon.

Laws that established the 'Superfund', the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and Superfund Amendments and Reauthorization Act (SARA), are used for removals and clean up of radioactively contaminated sites. EPA guidance establishes cleanup levels of soils contaminated with radiation from all sources including radium, thorium and uranium. Standards for hazardous waste disposal facilities could be used for disposing of certain types of TENORM. In a very few locations, based on State agency regulatory decisions, waste disposal sites created for chemically hazardous wastes under the Resource Conservation and Recovery Act (RCRA) can also be used for TENORM. EPA is currently working on ways to increase the number and kinds of sites available for low-activity and mixed chemical/radioactive waste disposal.

Regulations applicable to remediation of both inactive uranium mill tailings sites, including vicinity properties, and active uranium and thorium mills have been issued by the EPA under the Uranium Mill Tailings Radiation Control Act (UMTRCA). The NRC was required to adopt the EPA standards, and it uses those regulations to approve the closure of sites managing mill tailings, which then fall under the long term oversight and monitoring of the U.S. Department of Energy (DOE).

1.2. Other agencies

The DOE has the responsibility to protect human health and safety from the hazards of radiation and radioactive materials, including TENORM, associated with research, development and production activities on its own lands. However, the Department of Energy does not regulate TENORM at facilities where it is not the owner.

Other Federal land management agencies are responsible for clean up and control of radioactive materials on their lands by virtue of either enabling legislation, or requirements of the laws to protect land, air and water described above. The U.S. Department of Transportation (DOT) has developed regulations under a number of laws for the safe transportation of hazardous material (including radionuclides and TENORM) in intrastate, interstate and foreign commerce. Additionally, the Occupational Safety and Health Administration (OSHA) in the U. S. Department of Labor has developed standards to protect employees from exposure to ionizing radiation.

1.3. States

State authority to regulate radioactive materials including TENORM is based on the U.S. Constitutional law tenet that any authority or responsibility not specifically assigned to the Federal government may be exercised by the States. Many States actively regulate radioactive material through radiation control and other State programs. Control under State law includes naturally occurring and accelerator-produced radioactive materials and other sources of ionizing radiation. Most States also control radioactivity through programs authorized by the EPA to implement clean air, water and other environmental laws. Several States have asserted specific authority over TENORM, especially cleanup approaches and disposal. Approximately 13 States have developed regulations specifically for TENORM, though many of those are specific to oil and gas TENORM. Most States regulate TENORM under general rules for radiation protection.

2. OTHER ORGANIZATIONS-TENORM EFFORTS

Conference of Radiation Control Program Directors

Comprised of officials from State radiation control programs, usually health, natural resources or environmental agencies, the Conference of Radiation Control Program Directors (CRCPD) has developed a series of model regulations for States to use, either to implement Federal regulations, or to provide new radiation protection controls if Federal regulations are not available. A model regulation for control and licensing of TENORM materials was published by CRCPD, but EPA did not concur with its release due to some of the proposed radiation protection provisions.

Health Physics Society

A committee of the U.S. Health Physics Society has been developing a separate standard for TENORM radiation control, handling, transfer, storage, and disposal of those wastes and products. This professional organization is preparing its voluntary private sector consensus standard independently from the CRCPD, with the intention of getting it approved for inclusion as an American National Standards Institute (ANSI) professional environmental standard.

Interstate Oil and Gas Compact Commission and American Petroleum Institute

The Interstate Oil and Gas Compact Commission (IOGCC) is an association of State governors from oil and gas producing States responsible for promoting production, and examining regulatory issues for oil and gas at the State level. The IOGCC's Environmental and Safety Committee formed a (TE)NORM Subcommittee which provided guidance to be used by State oil and gas regulators in determining appropriate controls for the petroleum industry (TE)NORM [1]. On the private industry side, the American Petroleum Institute (API), an association for the U.S. oil and gas industry, has a (TE)NORM committee which has published a series of guidance reports for oil companies [2,3,4].

National Council on Radiation Protection and Measurements

The National Council on Radiation Protection and Measurements (NCRP) is a non-profit organization that formulates and disseminates information, guidance and recommendations on radiation protection. The NCRP has published a number of previous reports on TENORM including background radiation [5–8].

National Academy of Sciences

In 1996 and 1997, the U.S. Congress requested that EPA arrange for the U.S. National Academy of Sciences (NAS) to conduct a study to investigate the scientific and technical bases for EPA's TENORM guidelines. The NAS formed a committee that compared the existing guidelines for TENORM developed by EPA and other U.S. and international organizations concerned with radiation protection.

The NAS report [9] concluded that "differences in the guidelines for TENORM developed by EPA and other organizations are based essentially on differences in policy judgments for risk management". The NAS Committee also found that the information used to evaluate risk from ionizing radiation arising from TENORM and other (generally artificial) sources of ionizing radiation was, and should be, the same. The Committee noted additionally that, although a uniform national standard for TENORM exposure is desirable in order to achieve complete protection from TENORM — related hazards, development of such a standard probably is not possible for a variety of reasons, including the major differences in physical and chemical characteristics of the TENORM materials, and felt that EPA should concentrate its efforts on individual sources of TENORM.

3. WASTE DISPOSAL PRACTICES AND REGULATION

Disposal of TENORM wastes is regulated primarily by the States. As mentioned above, in a very few locations, waste disposal landfill sites created for chemically hazardous wastes under the Resource Conservation and Recovery Act can also be used for TENORM. Some facilities which are licensed by the Nuclear Regulatory Commission to receive radioactive waste may also be used for TENORM disposal including TENORM from Superfund cleanup locations— in addition to regulated, geotextile lined and water well monitored landfills, uranium mill tailings impoundments have also been used for this purpose after processing the waste to remove uranium content.

Additional disposal methods used for different types of TENORM produced by some industries are shown in Table I below.

TABLE I. DISPOSAL METHODS FOR SOME U.S. TENORM WASTES

INDUSTRY	TYPE OF WASTE	DISPOSAL PRACTICE	COMMENT
OIL AND GAS (also GEOTHERMAL ENERGY)	Pipe scale Sludges Produced water	Well injection to producing formation or into deep disposal wells Regulated radioactive waste landfills Underground salt domes Land spreading	Regulated by States, U.S. Clean Water Act, U.S. CERCLA and RCRA Proposed but not licensed yet Not recommended by EPA
DRINKING WATER	Ion exchange filters, Pipe scale, Sludge Residuals Backwash	Regulated radioactive waste landfills Sanitary Sewer system or On-site Lagoons Land spreading	Regulated by States U.S. Clean Water Act, U.S. CERCLA and RCRA May be restricted by States Not recommended by EPA

INDUSTRY	TYPE OF WASTE	DISPOSAL PRACTICE	COMMENT
COAL	Coal ash	Regulated radioactive waste landfills, Municipal landfills Recycling in building materials	Level of radioactivity may control disposal practice. Most U.S. coals have low levels of radioactivity.
PHOSPHATE	Phosphogypsum Slags	Placed in stacks	Regulated by U.S. Clean Air Act, States
URANIUM	Mill tailings Overburden, protore *In-situ* leach mine produced water & evaporites	Placed in tailing impoundments Placed in mine before closure Evaporation pit solids either buried on-site or sent to regulated landfill	Regulated by Uranium Mill Tailings Radiation Control Act State laws, CERCLA U.S. Atomic Energy Act, State laws

4. CONCLUSION

While there is no single U.S. law that regulates TENORM wastes and products, radiation protection and management controls exist through Federal and State regulation. U.S. Federal law regulates sources of radiation through a series of statutes that control exposures by the media (general major pathway) of exposure, be it air, water, or soil (as a waste). Specific controls exist for radioactive wastes from the oil and gas, phosphate, elemental phosphorous, and uranium industries. EPA is examining ways of expanding the numbers and types of waste disposal options available for receiving low activity wastes including TENORM.

APPENDIX

TABLE II. EXISTING U.S. REGULATORY STANDARDS AND GUIDANCES

Modified from [9] tables 7.1, 10.1, 10.2, and 10.4.

Guidance or Regulation	**Quantitative Criteria (limits)**	**Comments**
Radioactivity in water from community drinking water systems (Safe Drinking Water Act regulations)	Ra^{226} and Ra^{228} combined concentration of 0.19 Bq/l Total U concentration of 30 μg/l Alpha particle activity concentration of 0.56 Bq/l, including ^{226}Ra but excluding radon and uranium Beta particles and photon emitters annual dose of 0.04 millisieverts., excluding ^{228}Ra	Based primarily on cost benefit analysis for reducing existing levels of naturally occurring radionuclides in drinking water.
Radioactivity in liquid discharges (Clean Water Act regulations)	Concentrations in daily effluents of 0.37 Bq/l for dissolved ^{226}Ra, 1.11 Bq/l for ^{228}Ra and 4 mg/l for uranium Average concentrations in daily effluents over 30 days of 0.11 Bq/l for dissolved ^{226}Ra, 0.37 Bq/l for total ^{226}Ra, and 2 mg/l for uranium.	Limits from discharges from mines or mills used to produce uranium, radium, or vanadium ores. Based primarily on available effluent control technologies.
Standards for airborne emissions of radionuclides (Clean Air Act regulations)	Annual effective dose equivalent of 0.1 mSv for many Department of Energy (DOE) and non-DOE federal facilities, but excluding dose from ^{222}Rn and its decay products, and for emissions of ^{222}Rn from underground uranium mines. Annual emissions of ^{210}Po from elemental phosphorous plants of 7.4 to $16.65 x 10^{10}$ Bq. Emission rate of ^{222}Rn from specified radium bearing materials (such as phosphogypsum) of 0.74 Bq/m^3 per second. Phosphogypsum must be stored in stacks (piles) to isolate the waste from reuse and limit environmental impacts.	Based primarily on lifetime cancer risk to maximally exposed individuals of 10^{-4} and average lifetime risk in exposed populations of 10^{-6}.
Guidance on radon in homes, residential buildings and schools (now also includes sewage treatment plants and water treatment plants). (Radon Gas and Indoor Air Quality Research Act , and the Indoor Radon Abatement Act)	Mitigation for radon concentrations above 0.15 Bq/l. Mitigation for radon concentrations of 0.07 to 0.15 Bq/l if concentrations can be reduced below 0.07 Bq/l	Based on protection of individuals receiving highest exposures and cost-benefit analysis for reducing levels of radon in affected buildings.

Guidance or Regulation	Quantitative Criteria (limits)	Comments
Standards for uranium or thorium mill tailings (Uranium Mill Tailings Radiation Control Act)	Annual average release rate of ^{222}Rn to air of 0.74 Bq/m^2 per second or concentration of ^{222}Rn in air outside inactive DOE disposal sites of 0.02 Bq/l. Average concentration of ^{226}Ra in soil above background over an area of 100 m^2 of 1.9 Bq/g in top 15 cm or 0.56 Bq/g below 15 cm. Concentration of radon decay products indoors including background of 0.03 working level, with objective of 0.02 working level. Indoor gamma radiation level above background of 0.2 mSv. Concentrations in groundwater of ^{226}Ra plus ^{228}Ra of 0.19 Bq/l, alpha particle activity concentration of 0.56 Bq/l, and 1.11 Bq/l of combined uranium (under consideration for revision to new U maximum concentration limit of 30 µg/l).	Releases during uranium processing operations and from uranium mill tailings disposal sites before end of closure period must comply with dose constraints and concentration limits for liquid discharges. Based primarily on background levels of radioactivity in western U.S. and objective of reducing exposures of the public to as close to background levels as reasonably achievable; groundwater protection requirements are based on current and proposed drinking water standards.
Standards for operations of uranium fuel cycle facilities (regulations for environmental protection of uranium fuel cycle operations)	Annual dose equivalent of 0.25 mSv to whole body, 0.75 mSv to thyroid, and 0.25 mSv to any other organ.	Based primarily on doses judged reasonably achievable with available effluent control technologies
CERCLA guidance for cleanup of radioactively contaminated soils.	Combined ^{226}Ra plus ^{228}Ra, total U, and Th of 0.19 Bq/g above background.	Utilizes UMTRCA radionuclide concentrations, making them a health based standard suitable for radiation site cleanup.

REFERENCES

[1] INTERSTATE OIL AND GAS COMPACT COMMISSION, Naturally Occurring Radioactive Materials - Guidance Document and Summary of State Regulations for NORM in Oil and Gas. NORM Subcommittee of the Environment and Safety Committee, Tulsa (Undated).

[2] AMERICAN PETROLEUM INSTITUTE, NORM Disposal Cost Study, Publication 7100, First Edition. November 1996, API, Washington (1996).

[3] Management Of Naturally Occurring Radioactive Materials (NORM) In Oil & Gas Production, API Bulletin E2, April 1992, API, Washington (1992).

[4] ROGERS & ASSOCIATES ENGINEERING CORPORATION, "Management and Disposal Alternatives for NORM Wastes in Oil Production and Gas Plant Equipment," API Publication 7103, RAE-8837/2-2, May 1990, Washington (1990).

[5] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Radiation Protection in the Mineral Extraction Industry. NCRP Report No. 118, Bethesda (1993).

[6] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Exposure of the Population in the United States and Canada from Natural Background Radiation, NCRP Report No. 9, Bethesda (1988).
[7] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Exposures from the Uranium Series with Emphasis on Radon and its Daughters, NCRP Report No. 7, Bethesda (1984).
[8] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Natural Background Radiation in the United States, NCRP Report No. 45, Bethesda (1975).
[9] NATIONAL ACADEMY OF SCIENCES, Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials, Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials, National Research Council, National Academy Press, Washington (1999).
[10] CONFERENCE OF RADIATION CONTROL PROGRAM DIRECTORS, Part N, Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM). April 200, Frankfort, Kentucky (2004).

PAPERS PRESENTED AT THE TECHNICAL MEETING

SEPTEMBER 2002

UK REGULATIONS FOR NORM

R. SMITH
National Radiological Protection Board, Didcot, United Kingdom

Abstract

The paper summarizes the legislation and safety standards applied in the United Kingdom to the management of naturally occurring radioactive material (NORM).

1. INTRODUCTION

The primary UK legislation relating to the use of radioactive materials are the Radioactive Substances Act 1993 [1] and the Ionising Radiations Regulations 1999 [2]. These implement the European Union's Basic Safety Standards Directive (EUBSS) [3]. The Radioactive Substances Act 1993 [1] regulates the accumulation, storage and disposal of radioactive waste, principally to control potential doses to members of the public. The Ionising Radiations Regulations 1999 [2] deal primarily with regulating the doses that people receive at work. Both of these pieces of legislation apply to the use of materials containing naturally occurring radionuclides. Historically UK regulations relating to radioactive materials have covered both artificial and natural radionuclides.

1.1. The EU Basic Safety Standards

The European Union has its own set of regulations relating to radioactive materials (The Basic Safety Standards Directive, BSS, 1996) [3], which the UK had to bring its regulations into line with by May 2000. The primary scope of the EUBSS is "all practices which involve a risk from ionizing radiation from an artificial source or from a natural radiation source in cases where natural radionuclides are or have been processed in view of their radioactive, fissile or fertile properties". Therefore the general scope does not cover exposures due to natural radiation sources other than when these are part of the nuclear fuel cycle. However, paragraph 2 of Article 2 states that the Directive also applies to "work activities which involve the presence of natural radiation sources and lead to a significant increase in the exposure of workers or members of the public which cannot be disregarded from the radiation protection point of view". Title VII of the EUBSS expands on this by requiring each member state to identify work activities involving exposure to natural radiation sources that may be of concern from a radiological protection point of view and to apply the requirements of the Directive to the identified activities. The EUBSS therefore allows each member state a degree of discretion in this area.

The European Commission (EC) has, however, produced a document to assist in the implementation of Title VII, which gives reference levels for workplaces processing materials with enhanced levels of naturally occurring radionuclides [4]. This guidance is not binding on member states but it offers a simple technique for screening and categorizing the relevant industries based on radiation dose criteria. The guidance is limited to consideration of occupational exposures.

The guide proposes four control bands, as follows:

Band 1 no need to consider regulation;

Band 2 lower level of regulation should be applied;

Band 3 higher level of regulation should be applied; and

Band 4 process should not be permitted without a full individual assessment.

The four band system has three marker points to separate the bands related to the radiation doses workers receive. The doses chosen are 1 mSv/a, 6 mSv/a and 20 mSv/a under normal conditions, and 6 mSv/a, 20 mSv/a and 50 mSv/a under unlikely conditions. The guide therefore recommends that, for the relevant industries, if worker exposures are under 1 mSv/a under normal conditions no regulation is required.

1.2. The Radioactive Substances Act 1993

Under the provisions of RSA93 all work activities that use radioactive materials need to be registered, and the accumulation and disposal of waste authorized, unless the material is specifically excluded from RSA93. RSA93 covers work involving materials containing naturally occurring radionuclides; however, under Section 1 of RSA93, materials that have concentrations of naturally occurring radionuclides below those values presented in Schedule 1 of RSA93 are not considered to be radioactive and are therefore excluded from the provisions of the Act. Schedule 1 contains exclusion levels for solids, liquids and gases or vapours. Those for solid materials and gases or vapours are given, respectively, in Tables I and II. In addition to exclusion, there are a number of Exemption Orders (EOs) made under RSA93 that exempt specific materials from certain provisions of RSA93. Of particular relevance to industries that use or produce materials containing enhanced levels of naturally occurring radionuclides is the Radioactive Substances (Phosphatic Substances, Rare Earths etc.) Exemption Order 1962 [5]. This EO exempts certain materials containing naturally occurring radionuclides from the requirement for registration and authorization of accumulation and disposal under RSA93. The activity concentrations defined in this EO are given in Table I.

1.3. Ionising Radiations Regulations 1999

Regulation 3 (Application) of IRR99 makes it clear that the scope of the regulations includes work with radioactive substances containing naturally occurring radionuclides. The associated approved code of practice [6] provides more detailed guidance in this area. In the case of substances containing naturally occurring radionuclides used in work other than a practice*, e.g. steel plants, the regulations only apply if “their use is likely to lead to employees or other people receiving an effective dose of ionizing radiation in excess of 1 millisievert in a year”.

---

* In IRR99 a practice is defined as work involving the production, processing, handling, use, holding, storage, transport or disposal of radioactive substances; or the operation of any electrical equipment emitting ionising radiation and containing components operating at a potential difference of more than 5kV, which can increase the exposure of individuals to radiation from an artificial source, or from a radioactive substance containing naturally occurring radionuclides which are processed for their radioactive, fissile or fertile properties.

TABLE I: RSA93 SCHEDULE 1 AND RADIOACTIVE SUBSTANCES (PHOSPHATIC SUBSTANCES, RARE EARTHS ETC.) EXEMPTION ORDER (RSEO, 1962) ACTIVITY CONCENTRATIONS FOR SOLID MATERIALS

	Activity concentration (Bq g^{-1})	
Element	RSA93	EO
Actinium	0.37	14.8
Lead	0.74	14.8
Polonium	0.37	14.8
Protactinium	0.37	14.8
Radium	0.37	14.8
Thorium	2.59	14.8
Uranium	11.1	14.8

TABLE II: RSA93 SCHEDULE 1 ACTIVITY CONCENTRATIONS FOR GASES/VAPOURS

	Activity concentration (Bq per gramme of gaseous release)
Element	RSA93
Actinium	2.59×10^{-6}
Lead	1.11×10^{-4}
Polonium	2.22×10^{-4}
Protactinium	1.11×10^{-6}
Radium	3.70×10^{-5}
Thorium	2.22×10^{-5}
Uranium	7.40×10^{-5}

REFERENCES

[1] HER MAJESTY’S STATIONERY OFFICE, RSA (1993). The Radioactive Substances Act 1993, HMSO, London (1993).

[2] HER MAJESTY’S STATIONERY OFFICE, IRR (1999). Ionising Radiations Regulations 1999, HMSO, London (1999).

[3] EUROPEAN COMMISSION, Council Directive 96/29/Euratom of 13 May 1996 laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation, Off. J. Eur. Commun., L159 (1996).

[4] EUROPEAN COMMISSION (1999). Reference levels for workplaces processing materials with enhanced levels of naturally occurring radionuclides: A guide to assist implementation of Title VII of the European Basic Safety Standards Directive (BSS) concerning natural radiation sources, Radiation Protection 95, EU Luxembourg (1999).

[5] HER MAJESTY'S STATIONERY OFFICE, The Radioactive Substances (Phosphatic Substances, Rare Earths etc.) Exemption Order 1962, HMSO, London (1962).

[6] HEALTH AND SAFETY EXECUTIVE, Work with ionising radiation, Ionising Radiations Regulations 1999, Approved Code of Practice and Guidance, HSE, London (2000).

PROBLEMS IN REGULATION OF SAFETY DURING MANAGEMENT OF WASTE CONTAINING NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

M.V.MIHAJLOV, S.A.SITNIKOVZ
Federal Nuclear and Radiation Safety Authority (RF Gosatomnadzor), Moscow, Russia

Abstract

The paper describes the development and application of the regulation of safety standards to the management of NORM in Russia. The history of the development of the regulatory system is described briefly. The paper then lists the major areas of concern where potential safety issues have arisen and explains how the progress of introducing regulation and management change has been limited by resources and the attitudes of industry. However, there is an ever increasing number of licences being issued as awareness of the importance of safety issues in managing NORM are understood by industry. Finally the paper describes some of the outstanding issues, including the problems associated with legacy sites.

Up to recent times in Russia, regulation in the area of management of industrial waste containing naturally occurring radioactive material (NORM) had been carried out by those industry branches where this management took place. As a basis for such regulation they used the national basic radiation safety standards issued by Ministry of Health of the Russian Federation. These standards are based on recommendations of the ICRP publication 60 and fixed legislatively in the federal law “On Public Radiation Safety” according to which they came into force in 2000.

Gosatomnadzor of Russia did not participate actively in this regulation. It is connected with the fact that this radiation safety regulatory body is still rather young. The first decade of its existence (1992–2002) was devoted, basically, to formation of Gosatomnadzor of Russia as the regulatory body in the field of nuclear and radiation safety in the industry branches traditionally connected with production of nuclear energy, nuclear fuel and radioactive materials, and also with the management of nuclear and radioactive waste generated during this production.

It does not mean that Gosatomnadzor of Russia disregarded a problem of ensuring safety in industry branches where radioactive materials are present as accompanying, useless impurities, not used in the basic manufacturing processes and generating radioactive waste on the basis of NORM. On the contrary, during this period Gosatomnadzor of Russia collected the appropriate information about real radiation conditions at energy park and mining and reprocessing industry facilities in Russia, and also about results of regulation of radiation safety at these facilities, carried out by forces of these industry branches. In addition Gosatomnadzor of Russia had begun implementation of licensing and supervision of different aspects of the NORM management.

This information gathering has yielded the following results and has revealed the following problems in regulation and ensuring control of radiation safety at facilities with NORM.

The oil, gas, coal, artesian water and other minerals mining and reprocessing processes change the properties of many materials containing NORM. The redistribution of NORM leads to inhomogeneities: concentration of some and pauperization of other materials. The physical and chemical properties of compounds containing NORM are changed too: they become more chemically active and increase their migration ability. It is especially the case for cycles of extraction and initial reprocessing of oil and gas, where NORM concentration can increase by more than 100 times due to their sedimentation and accumulation in the equipment. As a result of this, the equipment, installations and constructions where such processes take place can become dangerous radiation sources.

Their effect is shown not only by creation of hazardous radiation conditions during maintenance and repair of the equipment, but also by increase in the background radioactivity of the site territory. The long half-life periods of radionuclides, their multi-stage nuclear decay, the presence of different types of radiation and the formation of gaseous radon in a decay chain promote serious man-made changes in background radioactivity.

The effects of such hazardous radiation factors at facilities leads to an external exposure of the personnel and the public due to NORM on the walls of equipment and in storage facilities for contaminated waste, and to an internal inhalation exposure due to the presence of NORM and their decay products in the air. This arises at contaminated waste storage facilities and at the contaminated part of facilities sites under conditions of normal and emergency operation modes.

Since the harmful effect of NORM at mining facilities was revealed and realized a long time ago, it is taken into account already at the stage of design and exploration work. And this essentially facilitates the solution of problems related to ensuring radiation safety. However, for various reasons, essential difficulties arose in technologies of the energy park, particularly oil extracting, burning of coal, and extraction of artesian water.

The main reason lies with unavailability of a comprehensive legal and regulatory basis for ensuring radiation safety. The previous legal and regulatory basis was department-oriented, closed and, in essence, concealed the danger of man-made NORM concentration. It also ignored the universally recognized concept of a non-threshold effect of ionizing radiation on man, i.e. it did not take into account the effect of small doses of exposure. One more feature was that under conditions of the centralized economy, the responsibility for ensuring radiation safety was assigned to the ministries and departments, instead of operating organizations (operators). Individual persons or the population as a whole, who were or could be exposed to radiation, did not have right to receive information about this, much less to demand the creation of safe conditions of operating and residing.

The situation concerning the legal and regulatory base changed radically since the adoption in the 1990s of the federal laws “On Public Radiation Safety” and “On the Use of Nuclear Energy” and also of new national safety standards — the Radiation Safety Standards (NRB-99), based on ICRP publication 60, and the Basic Health Rules for Ensuring Radiation Safety (OSPORB-99) which, in contrast to earlier existing standards, defined the basic criteria and requirements for protection of personnel and the public against the effects of natural radiation sources.

However, the further development of the existing regulatory base for ensuring radiation safety of facilities with NORM up to level of safety guides now has been essentially slowed down. The technical support organizations of radiation safety regulatory bodies have proved to be not ready for comprehensive development of the regulatory base for these facilities or for development of the concept of ensuring radiation safety of personnel, the public and the environment, taking into account specifics of NORM in contrast to man-man radionuclides.

In this situation Gosatomnadzor of Russia is compelled to implement a conservative approach to regulation of radiation safety at these facilities on the basis of criteria and requirements existing in branches of the energy park in the field of low and intermediate radioactive waste management. Simultaneous development of separate safety guides has been begun, one of which, namely, “Safety Ensuring in Management of Radioactive Waste Generated during Extraction, Processing and Use of Minerals” was developed and put into effect in 2000.

Implementation of such an approach is complicated by the unavailability and unwillingness of operating organizations to develop and to introduce technologies and equipment for the management of radioactive substances that comply with safety requirements existing in the energy park, into the basic technological processes, which are designed and carried out without taking into account NORM availability.

Many of these operating organizations in their own way are anxious about radiation safety of personnel, the public and the environment in areas of their location. The facilities work on development of technologies and equipment for removal of radioactive impurities from production and organize monitoring of exposure of personnel and radioactive contamination of workplaces and the environment.

At the same time, the separate operating organizations counteract the organization of licensing and supervision according to a procedure established in Russia for operating organizations of the energy park in accordance with requirements of the law “On the Use of Nuclear Energy”. Their motivation is based on the fact that their main activity is not connected with the use of atomic energy and accordingly is not under jurisdiction of the law “On the Use of Nuclear Energy”. Therefore these operating organizations consider that they are not under supervision of Gosatomnadzor of Russia and that the requirements, existing in branches of an energy park, do not concern them. In their opinion, these requirements are developed for branches in which the management of man-made radionuclides is carried out. Because these artificial radionuclides are distinct from NORM, so, accordingly, their requirements differ from those requirements that can be placed on facilities with NORM.

The real reason behind this motivation is that implementation of safety requirements at these facilities will result in an essential increase of capital investments and a significant increase in price of their products and decrease in profitability of production.

However, the measures taken by Gosatomnadzor of Russia nevertheless means that the number of the facilities of energy parks that have obtained and are obtaining licences of Gosatomnadzor of Russia is gradually being increased.

Among the further tasks in the field of safety regulation ensuring in management of waste with NORM, Gosatomnadzor of Russia sees the following one – organization of development of the regulatory documents to oblige all operating organizations whose main activity is connected with NORM, to provide for development and implementation of a full cycle of measures for safe NORM handling, including collection, transportation and disposal of waste containing NORM. These measures should provide for forecasting NORM occurrence, and also development and introduction of the appropriate technological processes on safe NORM handling during the design of new facilities and modernization of the existing facilities.

The solution of this problem should be accompanied by revealing such facilities and establishing state supervision of ensuring radiating safety, including licensing within the framework of the law “On the Use of Nuclear Energy”.

Separate discussion is needed on the question of radiation safety regulation on sites of facilities that no longer exist. Currently the operating organization is not responsible for safety. By virtue of the economic situation existing now, described by decentralization of economy and bankruptcy of the unprofitable facilities, there are many such facilities in Russia at present. In addition, some regional administrations in whose territory such enterprises are located and who, according to law, are responsible for safety, are unable to realize this responsibility because of unsatisfactory status of their budget. This issue is due to the sharing of competence between regulatory bodies in the field of nuclear energy use and does not concern the competence of Gosatomnadzor.

In conclusion we sum up results of the assessment of the current state-of-the-art in Russia in the field of safety regulation of NORM management in energy parks by listing some of the basic problems which, in opinion of Gosatomnadzor, hinder the assurance of comprehensive safety:

- Absence of the concept of ensuring radiation safety in NORM management in the non-nuclear industries, which would allow safety requirements existing in a energy park to be extended to NORM management or to define distinction between them;

- As consequence of the previous problem, insufficiency of regulatory base for ensuring safety in NORM management in the non-nuclear industry;

- The certain resistance of operating organizations to placing safety regulatory requirements existing in branches of an energy park on them;

- Uncertainty of the approach to regulation of radiation safety at facilities that no longer exist.

LIST OF PARTICIPANTS
2002 AND 2004 MEETINGS

Al Khayat, T.A.H.	Ministry of Science and Technology, Iraq
Byron, D.	International Atomic Energy Agency
Collier, D.	Metallurgist, Australian Nuclear Science & Technology Organisation (ANSTO), Australia
Cortes Carmona, A.	Comision Nacional de Seguridad Nuclear y Salvaguardias (CNSNS), Mexico
Debauche, A.	Institut National des Radioéléments (IRE), Belgium
Delporte, V.	Direction Générale de la Sûreté Nucléaire et de la Radioprotection, France
Dos Santos, A.	Researcher, Instituto de Pesquisas Energéticas e Nucleares-IPEN-CNEN/SP, Brazil
Elegba, S.	Nigerian Nuclear Regulatory Authority, Nigeria
Ettenhuber, E.	Bundesamt für Strahlenschutz (BfS), Germany
Falck,W. E.	International Atomic Energy Agency
Fernandes, H.R.	Instituto de Radioproteção e Dosimetria (IRD/CNEN), Brazil
Frankin, M.	Instituto de Radioproteção e Dosimetria (IRD/CNEN), Brazil
Gehrcke, K.	Institut für Angewandten Bundesamt für Strahlenschutz (BfS), Germany
Gheorghe, L.	National Uranium Company S.A., Romania
Israelson, C.	National Institute of Radiation Hygiene, Denmark
Jurina, V.	Public Health Authority of the Slovak Republic, Slovakia
Koblinger, L	Hungarian Atomic Energy Authority, Hungary
Koukouliou, V.	Greek Atomic Energy Commission, Greece
Krizman, M.	Slovenian Nuclear Safety Administration (URSJV), Slovenia
Kubelka, D.	State Office for Radiation Protection, Croatia
Lada, W.	National Atomic Energy Agency (NAEA), Poland
Lambert, P.	Belgian Agency for Rad. Waste & Enriched Fissile Mat. (ONDRAF/NIRAS), Belgium

Lee, S.H.	Korea Institute of Nuclear Safety (KINS), Republic of Korea
Liebenberg, G.	Nuclear Liability Management Division, South Africa Nuclear Energy Corporation Ltd. (NECSA), South Africa
Lokner, V.	APO Ltd. Environmental Services, Croatia
Lubis, E.	National Nuclear Energy Agency, Indonesia
Madden, J.	Radiological Protection Institute of Ireland (RPII), Ireland
Mallah, M.	Atomic Energy Organization of Iran (AEOI), Iran
Maniyan, C.	Atomic Energy Regulatory Board, India
Menon, S.	Menon Consulting AB, Sweden
Merta, A.J.	National Atomic Energy Agency (NAEA), Poland
Mutawa, A. Al	Ministry of Electricity and Water, United Arab Emirates
Necheva, C.	State Enterprise, Bulgaria
O'Brien, R.	Australian Radiation Protection & Nuclear Safety Agency (ARPANSA), Australia
Paganini Fioratti, M.	Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici, APAT, Italy
Pires do Rio, M.A.	Instituto de Radioproteção e Dosimetria (IRD/CNEN), Brazil
Pontedeiro, E.M.	Comissao Nacional de Energia Nuclear (CNEN), Brazil
Pungut, N.	Atomic Energy Licensing Board (LPTA), Malaysia
Ramachandran, T.	Atomic Energy Regulatory Board, India
Reisenweaver, D.	International Atomic Energy Agency
Robles, B.	CIEMAT, Spain
Servant-Perrier, A.	Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France
Setlow, L.	U.S. Environmental Protection Agency (EPA), United States of America
Simmons, C.	Thompson & Simmons PLLC., United States of America
Simón, I.	Consejo de Seguridad Nuclear (CSN), Spain
Sitnikov, S.	Federal Nuclear & Rad. Safety Authority of Russia (RF GOSATOMNADZOR), Russian Federation

Smith, K.	Health Protection Agency (HPA), United Kingdom
Söderman. A-L	Swedish Radiation Protection Authority (SSI), Sweden
Strand, T.	Norwegian Radiation Protection Authority, Norway
Stensrud, H.	Norwegian Radiation Protection Authority (NRPA), Norway
Suman, H.	Syrian Atomic Energy Commission (SAEC), Syria
Teng, I.L.	Atomic Energy Licensing Board (AELB), Malaysia
Thierfeldt, S.	Brenk Systemplanung GmbH, Germany
Tiefenbach, W.	Radiation Protection Bureau, Canada
Tomas, J.	Centro de Protección e Higiene de las Radiaciones (CPHR), Cuba
Tothill, S.	RWE NUKEM Consulting, United Kingdom
Waggitt, P.	International Atomic Energy Agency
Van der Steen, J.	Nuclear Research & Consultancy Group (NRG), Netherlands
Van der Westhuizen, A.	P.O. Box 5290, Lydenburg, South Africa
Vidya Sagar, D.	Atomic Energy Regulatory Board, India
Yucel, B.	Turkish Atomic Energy Authority, Turkey
Zamokwakhe, Z.	National Nuclear Regulator (NNR), South Africa
Zarkasi, A.	Nuclear Energy Control Board, Indonesia
Zituta, Z.	National Nuclear Regulator (NNR), South Africa