DEVELOPMENTS IN RADIATION PROTECTION REGULATION RELEVANT TO MANAGEMENT OF NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM)

Scope of Regulation – National Directory for Radiation Protection, Edition 2

The second edition of the *National Directory for Radiation Protection* is nearing completion.

The section on scope of regulation included in the first edition is being amended to reflect the exemption protocol discussed at the National Conference on Radiation Protection in Mining and Mineral processing in April 2005. The current second edition draft of that section is at Attachment A.

The scope of regulation first defines exposures that are not amenable to control and are *excluded* from regulation. The exposures from 'unmodified' concentrations of radionuclides in most raw materials have been excluded in the first edition of the *National Directory*.

Footnote 1 in the scope of regulation in the draft second edition at Attachment A applies the concept of exclusion from the regulatory framework to materials with radionuclides of natural origin below 1 Bq/g (head of chain). Such materials would thus not be within the framework of radiation protection regulation at all. The footnote is qualified by referring to this exclusion applying 'for normal exposure situations'.

This footnote is intended to reflect the international guidance with regard to exclusion of radionuclides of natural origin established in the IAEA Safety Guide RS-G-1.7 *Application of the Concepts of Exclusion, Exemption and Clearance.* The qualification of 'for normal exposure situations' refers to the discussion in para 5.1 of RS-G-1.7 that 'there are some situations (such as the use of some building materials containing natural radionuclides) for which exposures from materials due to radionuclides with activity concentrations below those given in Table 1 would necessitate consideration by the regulatory body for some types of regulatory control.'

The scope of regulation addressed in the *National Directory* then addresses radioactive material or practices that are *exempted* from regulation. The scope defines the general basis for exemption as being that:

(a) the health risks associated with the source, practice, or type of person using a source are sufficiently low as to be of no regulatory concern; and

(b) radiation protection, including the cost of regulatory control, has been optimised.

There are then defined specific instances of exemption. The exemption provision most likely to be of relevance to NORM is that in paragraph 3.2.3. This allows the regulator to exempt material or practices that are not automatically exempted (because they involve materials above the international exemption limits stated in the *National Directory*). This exemption in paragraph 3.2.3 would flow from an assessment of the optimisation of protection that shows that exemption is the optimum solution. In other words, if there is nothing that can be reasonably achieved through full regulation in terms of magnitude of individual doses, the number of people exposed and the likelihood of exposure, then the material or practice should be exempted, possibly with conditions about monitoring and reporting.

PO Box 655
MIRANDA NSW 1490
Phone +612 9541 8333
Fax +612 9541 8314

E-mail: info@arpansa.gov.au **Web:** www.arpansa.gov.au
Freecall: 1800 022 333 (a free call from fixed phones in Australia)

619 Lower Plenty Road
YALLAMBIE VIC 3085
Phone +613 9433 2211
Fax +613 9432 1835

More precision is proposed to be added to this provision through footnote 8 of the draft second edition of the *National Directory.* This footnote states that 'Exemptions will be granted for practices (generally expected to be dealings involving quantities of naturally occurring radioactive materials) resulting in individual doses up to about 1 mSv per year on the basis of an assessment to be agreed between the operator and the Authority that the radiation protection is optimised.'

Where exemption is not warranted and regulation applies, Para 3.2.5, together with proposed footnote 10 in the draft second edition, requires that a graded approach commensurate with hazard should be applied where it is determined that regulatory controls will apply.

It is expected that the 2nd edition of the *National Directory* will be approved by the Radiation Health Committee for public comment in the final quarter of 2006 with it being adopted during 2007. The Commonwealth, States and Territories are committed to apply the provisions of the *National Directory* once approved.

In summary, it can be expected that once the 2nd edition of the *National Directory* is adopted, there will be a broad regulatory framework available in Australia for addressing management of NORM. The framework would include:

- Exclusion from regulation of NORM at less than 1 Bq/g (head of chain)
- A process for (conditional) exemption from regulation in circumstances where protection was optimised but that there were individual doses up to about 1 mSv/year
- A graded approach commensurate with hazard for NORM where regulatory controls were required to be applied.

The form of regulatory control that might be applied to practices involving NORM can be found in the publication *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Minerals Processing* (ARPANSA, RPS 9, 2005). This 'Mining and Minerals Code' is discussed in the next section.

Radiation Protection Series 9 – the Mining and Minerals Code

The background to the development of the new Mining and Minerals Code can be found in chapter 1 of the RPS 9 publication. The publication consists of a Code of Practice that establishes regulatory requirements and a Safety Guide that provides further information and guidance to meet the requirements of the Code.

Importantly, the section of the Code that establishes the scope of its application (section 2.3) inter alia states:

The provisions of this Code apply to the mining and processing of ores for the production of uranium or thorium concentrates, and the separation of heavy minerals from mineral sands ore.

The relevant regulatory authority (see Annex A) ***may direct that this Code be applied, in whole or part, to other mining and mineral processing operations that have the potential to produce significant occupational radiation exposures, or to generate waste having the potential to cause a significant increase in the radiological exposure of members of the public or the environment*** *and which would therefore require specific management. These operations may include:*

(a) the mining and processing of other minerals that adventitiously contain uranium or thorium or their decay products; and
(b) processes which lead to the production of waste not usually regarded as radioactive, but which contains naturally occurring radionuclides.

The Safety Guide suggests that 'other mining and mineral processing operations' to which the Code may be applied may include 'the mining and processing of phosphate ores, tin, tantalum, and other non-ferrous ores, coal, and oil and gas extraction.'

The Code refers to exemptions in whole or part from its provisions in section 2.4. Guidance is given in section 3.5 of the Safety Guide.

The broad requirements that would be imposed by application of the Code are:

- application of the radiation protection standards established in RPS 1
- preparation and approval of a radiation management plan
- preparation and approval of a radioactive waste management plan, where applicable
- stated responsibilities for the operator/employer and employees.

Another requirement that is peculiar to NORM is the need to assess the current or projected use of a material that is regarded as a residue containing NORM and that currently is, or has the potential to be, recycled.

The Mining and Minerals Code, supported by the Safety Guide, establishes the regulatory framework that would be applied to regulation of NORM, where this is required under the framework established by the *National Directory.*

International Developments

International Atomic Energy Agency (IAEA): safety standards, safety reports and co-ordinated research projects

The IAEA is preparing a safety standard currently titled *Management of NORM Residues* (Draft Safety Guide DS 352). This is being designed to expand the scope of and to supersede the existing safety guide *Management of Radioactive Waste from the Mining and Milling of Ores* (WS-G-1.2). It aims to provide guidance on the management of all mining and raw materials processing residues (including residues designated as waste) that, in terms of the IAEA safety standards are subject to regulatory control due to the levels of radionuclides of natural origin contained within them.

The issues that are being addressed in the drafting of this document include:

- an appropriate legal and organisational framework within which NORM residue management activities can be planned and carried out safely and a national policy for managing NORM and NORM residues
- the establishment of a national inventory of processes generating NORM residues
- the applicability of requirements and the scope of regulatory control to NORM residues. The draft refers to the exclusion level of 1 Bq/g (and also to the exemption levels in the transport requirements). The discussion of exemption currently states that 'it should normally be unnecessary to apply regulatory controls to activities involving exposure to NORM if the

effective dose received by a worker or member of the public does not exceed about 1 mSv in a year.'

- Strategies for NORM residue management, including for bulk minerals processing residues, mineralised waste rock and similar residues, contaminated items, and manufactured items containing NORM
- Environmental monitoring and surveillance.

At this stage the guidance being developed in DS 352 seems consistent with Australia's approach through the *National Directory*, the *Mining and Minerals Code* and the framework set in the CEO of ARPANSA's response to the report of the Radiation Health and safety Advisory Council on NORM.

It is expected that a draft of DS 352 will be formally circulated for IAEA Member State comment towards the end of 2006.

Other IAEA safety standards that are relevant to NORM management include:

- RS-G-1.7 *Application of the Concepts of Exclusion, Exemption and Clearance*
- RS-G-1.6 *Occupational Radiation Protection in the Mining and Processing of Raw Materials*
- WS-R-3 *Remediation of Areas Contaminated by Past Activities and Accidents* and an accompanying safety guide (DS 172) now approved for publication.

Issues about exposures to radiation from natural sources are also being explored in the IAEA in the context of developing a revision of the *Basic Safety Standards.*

The IAEA is also developing 'safety reports' in relation to NORM. Safety reports are documents below the level of the safety standards series that discuss developing safety issues. In progress is an overarching safety report *Assessing the Need for Radiation Protection Measures in Work involving Minerals and Raw Materials.* This was developed by a consultants' meeting in January 2006 that included an ARPANSA representative. The document was completed at the meeting and is now in the process of final editing and publication. This report forms an overarching publication that will have a range of associated industry-specific safety reports developed to accompany it. The industries to be covered in these reports are planned as follows:

- oil & gas (published)
- zircon/zirconia industry (in development)
- rare earths
- mineral sand processing
- metals industries (e.g. niobium, tantalum. bauxite,....)
- phosphate industry
- titanium dioxide industry
- thorium industries and uses
- coal/ash industry

Australian industry representatives have been sought for the mineral sands and rare earth reports, which are planned to start soon.

The IAEA has established a Coordinated Research Programme (CRP) on the transport of natural materials. In July 2003 the International Conference on the Safety of Transport of Radioactive Material addressed issues associated with the safe transport of radioactive material. Among the issues identified for further work was reconsideration of the applicability of transport regulations to naturally occurring radioactive material (NORM). The Conference identified a need for additional research to relieve unnecessary regulatory burdens related to the transport of very low activity NORM. Since the 1996 edition of the IAEA Transport Regulations introduced radionuclide-specific exemption levels in lieu of the single 70 Bq/g value, ores, tailings, and backfill from large mining operations (e.g. phosphate, coal, gold and monazite) have been brought within the scope of the Regulations. To address this situation, the 1996 Regulations included an allowance for a factor of 10 higher than the exemption quantities for naturally occurring materials, provided they are not intended to be processed to extract the naturally occurring radionuclides. The Conference noted the potential inconsistency between this provision and the developing international guidance on the more general issue of the scope of regulatory control in RS-G-1.7, the problems associated with determining the ultimate use of the material, and the inconsistency of excepting doses associated with some types of source (e.g. naturally occurring radioactive material - NORM) but not doses of the same magnitude from other types of source. The Conference suggested that the full impact of and technical basis for the 'factor of 10' exemption be thoroughly researched.

Subsequent to the Conference, the Board of Governors approved the Action Plan for Safety of Transport of Radioactive Material which requires the Secretariat to initiate a CRP on the appropriate regulatory control for the safe transport of NORM. Additionally, the Transport Safety Standards Committee recommended initiating this CRP in March 2004.

The results of the CRP may be used to revise the Regulations or to develop guidance material in TS-G-1.1 to address transport and packaging of NORM. Several countries have agreed to participate. A request to participate involves submitting a project plan to the IAEA. ARPANSA is considering how Australia might be able to participate in the CRP.

Finally, the Environmental Modelling for Radiation Safety (EMRAS) project is essentially a CRP on environmental modelling. An ARPANSA staff member is a member of the EMRAS working group on NORM. The outcome of this project will be a series of Technical Reports expected to be published in 2008-09.

International Commission on Radiological Protection (ICRP)

The ICRP is the authoritative body that recommends on the radiation protection framework and its application in various circumstances. From time to time, its overall radiation protection framework is set out in Recommendations. The framework may then be adopted into regulatory structures by countries and established by the IAEA. Thus, Australia's radiation protection standard as described in RPS 1 is based upon the 1990 Recommendations of the ICRP as are the IAEA's Basic Safety Standards.

The ICRP has been in the process for quite some time of preparing new Recommendations. The most recent (June 2006) draft of these Recommendations is now available for comment.

Of particular interest with regard to NORM are the Commission's discussions of exclusion and exemption from regulation, and exposure to natural sources.

The Commission 2006 draft bases the concepts of exclusion and exemption upon amenability for an exposure to be controlled with regulatory instruments in the case of exclusion and situations that are unwarranted to be controlled because the associated risk is negligible under any circumstances in the case of exemption. Lying behind this discussion is the Commission's fundamental principle that radiation protection must be optimised – that radiation exposures must be as low as reasonably achievable, economic and social factors being taken into account. Exemption addresses the 'reasonable achievability' of radiation control through regulation.

In its discussion on exclusion and exemption, the Commission in the 2006 draft is not firm about exposures to naturally occurring radioactive materials. It states that:

> *The decision as to what exposures are not amenable to control requires a judgment by the legislator, which may be influenced by cultural perceptions. For instance, national attitudes to the regulation of exposures to natural occurring radioactive materials are extremely variable.*

With regard to exemption, the Commission emphasises that it is not simply about triviality of risk, but to the broader notion of control being unwarranted. The draft states:

> *The Commission considers that exemption should not be entirely linked to triviality of risk because it is a broader concept that refers to unwarranted control due to any reason. Reasons for regulatory exemption include, but are not limited to, triviality of risk. The criterion for deciding whether or not regulatory controls are warranted has multiple attributes and should be situation specific. It should not be determined only by a dose level but by also taking account of other factors involved in controlling exposure. It should not be surprising that different circumstances could lead to different dose levels below which regulatory control is considered unwarranted. National regulators should decide the criteria for exemption on a case-by-case basis and the dosimetric boundary of 10 μSv y^{-1} should be only one of the criteria used.*

The 2006 Commission draft discusses exposure to natural sources, including industries involving exposures to NORM. In general, the Commission recommends that such industries be considered within the framework of its system for radiological protection (including exclusion and exemption). This may be straightforward enough in the case of new facilities for the processing of ores etc but may raise more difficult issues where there are existing or legacy practices and particularly on the case of accumulated waste residues from historical operations. The Commission supports a graded approach to regulation, where such regulation is found necessary.

The Commission has also discussed the issues of exclusion, exemption and clearance and the scope of regulatory control in detail in a draft document published for comment via their web site.

Next Steps in NORM Management in Australia

ARPANSA proposes to develop a Safety Guide on Management of NORM as a Radiation Protection Series publication. The Safety Guide will contain general guidance on NORM management against the background of the regulatory structure established by the *National Directory*, edition 2 and the Mining and Minerals Code.

Annexes to the Safety Guide will address specific industries where the management of NORM is likely to be addressed. Each industry Annex would:

- seek to identify the levels of NORM in various industries in products, by-products and residues – much of this was done in the Council Discussion paper http://www.arpansa.gov.au/pubs/norm/rhsac_disc.pdf and the Cooper Report http://www.arpansa.gov.au/pubs/norm/cooper_norm.pdf although the data on some industries was pretty sparse.
- identify current approaches to NORM management in the industry
- provide relevant data on exposures etc – need to consider what we can/should do, who would do it etc
- review international guidance/current projects that could be relevant
- review possibility/need for exemptions/guidance/regulation.

Each Annex would be developed in close consultation with the industry concerned.

It is proposed that the first three annexes cover:

- oil and gas production
- phosphate (fertiliser and phosphogypsum)
- bauxite processing (red mud)

These industries have been suggested on the basis that work has already been carried out to assess risks from exposure to NORM in products, by-products and residues. The oil & gas and phosphate industries have the additional characteristic that there is a disequilibrium between members of the radionuclide decay chains in the formation water (oil & gas) and between process streams (fertiliser and phosphogypsum) respectively.

A draft document development plan (DDP) for the proposed Safety Guide is at Attachment B. After consultation with industry, the draft DDP will be considered by the Radiation Health Committee at its meeting in October 2006.

ARPANSA
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3. Scope of Regulation

3.1 Exclusions

The following exposures whose magnitude or likelihood is essentially not amenable to control through legislation are excluded from regulation:

(a) K-40 in the body;

(b) cosmic radiation at the surface of the earth; and

(c) unmodified concentrations of radionuclides in most raw materials, unless otherwise specifically identified in this Directory[1].

3.2 Exemptions

3.2.1 The general criteria for granting an exemption are:

(a) the health risks associated with the source, practice, or type of person using a source are sufficiently low as to be of no regulatory concern; and

(b) radiation protection, including the cost of regulatory control, has been optimised[2].

3.2.2 The criteria to exempt radioactive material[3] or practices from notification, registration and licensing are:

(a) The radioactive material has an activity concentration[4] less than that prescribed in Schedule 4[5] or consists of or contains less than the activity prescribed in Schedule 4, or

(b) the radioactive material has an activity concentration greater than that prescribed in Schedule 4 or consists of or contains greater than the activity prescribed in Schedule 4, but causes an annual effective dose to an individual member of the public of less than 10 μSv, and a collective effective dose to the critical group committed by one year of performance of the practice, as determined by the Authority, of less than 1 person.Sv[6], or

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1 For normal exposure situations, the concept of exclusion generally applies to exposures from materials with radionuclides of natural origin below 1 Bq/g.

2 For ionizing radiation optimisation means, in relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received are all kept as low as reasonably achievable, economic and social factors being taken into account. For non-ionizing radiation, optimisation can be equated to cost-effectiveness.

3 The definition of radioactive material and the exemption levels for activity and activity concentration for particular radionuclides in this Directory are based on those of the International Atomic Energy Agency. The rationale for the definition and exemption levels is provided in Annex 2.

4 The 'activity concentration' of a radionuclide means the activity per unit mass of the material in which the radionuclide is essentially uniformly distributed. [A sealed source in a lead surround does not constitute being uniformly distributed].

5 All dealings with all radioactive material below the activity concentration or activity levels in Schedule 4 of the Directory are exempt from regulation without approach to the Authority. In relation to the transport of radioactive material, the exemption levels established in the *Code of Practice for the Safe Transport of Radioactive Material* apply.

6 Subject to the agreement of the Authority on the applicable scenarios and method of calculation to be applied, dealings with radioactive materials involving activity concentrations or activities greater than Schedule 4 but which are demonstrated through the calculation of doses from applicable scenarios to result in doses similar to those on which Schedule 4 is based are exempt.

(c) in the case of a mixture of radioactive materials, where each of the radioactive materials present does not exceed the individual activity or activity concentration, the mixture is defined as exempt if the sum of the fractions obtained by dividing the activity of each material present by the appropriate activity value from Schedule 4, or the sum of the fractions obtained by dividing the activity concentration of each material present by the appropriate activity concentration value from Schedule 4, does not exceed 1.

(d) in the special case of exposure to naturally-occurring radon-222 in the workplace, the long-term average concentration of radon-222 is less than 1000 Bq/m^3.

3.2.3 The Authority may exempt material or practices that are not exempt under 3.2.2 above, subject to conditions that may be determined by the Authority[7], where an assessment for the optimisation[9] of protection shows that exemption is the optimum option[8]. When this provision is used, the Authority must notify the Radiation Health Committee (RHC) immediately after granting the exemption.

3.2.4 The Authority may declare material or practices otherwise exempt under 3.2.2 above to be subject to the legislation if an assessment of the magnitude of individual doses, the number of people exposed and the likelihood that potential exposures will actually occur justify the practice being subject to the legislation[9]. When this provision is used, the Authority must notify the Radiation Health Committee immediately after making such a declaration.

3.2.5 Where the Authority has determined that regulatory controls will apply, the stringency of the regulatory measures should be proportionate to the degree of risk associated with the material[10].

3.2.6 A radiation generator or electronic tube, of a type approved by the Authority, must be exempted from the notification, registration or licensing requirements specified, provided that:

(a) in normal operating conditions it does not cause an ambient dose equivalent rate or a directional dose equivalent rate, as appropriate, exceeding 1 $\mu Sv\ h^{-1}$ at a distance of 0.1 m from any accessible surface of the apparatus; or

(b) the maximum energy of the radiation produced is no greater than 5 keV; or

(c) the apparatus is listed in Schedule 5.

3.2.7 A radioactive source listed in Schedule 5 must be exempted from the notification, registration or licensing requirements specified.

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7 When an exemption is granted, the Authority should be able to impose appropriate conditions on the exemption, such as requirements for reporting and monitoring.

8 Exemptions will be granted for practices (generally expected to be dealings involving quantities of naturally occurring radioactive materials) resulting in individual doses up to about 1 mSv per year on the basis of an assessment to be agreed between the operator and the Authority that the radiation protection is optimised. Such an exemption may be subject to monitoring and reporting conditions to ensure that the basis for the exemption remains in place.

9 Material or practices otherwise exempted through the operation of Schedule 4 of the Directory will only be subjected to regulation if the Authority can demonstrate that the magnitude of individual doses, the number of people exposed and the likelihood that potential exposure will occur significantly exceed the values upon which the exemptions in Schedule 4 are based.

10 A graded approach will be applied to material and practices commensurate with hazard.

Document Development Plan for a Radiation Protection Series Publication

1. IDENTIFICATION

Category:	Safety Guide
Proposed action:	Develop a new Safety Guide and annexes
Existing title:	New
Proposed title:	Safety Guide on the Management of NORM
RHC Member responsible:	J Loy

2. BACKGROUND & ISSUES

Naturally-occurring radioactive material (NORM) is the term used to describe materials that contain radionuclides that exist in the natural environment. The radionuclides of interest include long-lived radionuclides such as uranium-238 (^{238}U), uranium-235 (^{235}U) and thorium-232 (^{232}Th) and their radioactive decay products (such as isotopes of radium, radon, polonium, bismuth and lead), and individual long-lived radionuclides such as potassium-40 (^{40}K), rubidium-87 (^{87}Rb) and indium-115 (^{115}In). These radionuclides have decay times which are comparable with or larger than the age of the earth, so they have always been present in the earth's crust and within the tissues of all living species. Where materials contain radionuclides from the naturally occurring decay chains (^{238}U, ^{235}U, ^{232}Th), the large number of radionuclides in each chain, and the resulting large range of physical and chemical properties of the individual radionuclides, means that there can be a highly variable degree of secular equilibrium between the individual members of the chains.

NORM is widely distributed, and gives rise to a natural radiation background that varies by approximately two orders of magnitude over the Earth, and even more if localised mineral deposits are taken into account. This means every living species is exposed to this radiation, and in most situations this exposure is not amenable to control. There appears to be no scientific evidence relating general variations in this natural background to health effects.

The world-wide average activity concentrations of some of the naturally occurring radionuclides in the undisturbed environment are given in Eisenbud (1987). For the two most important naturally occurring decay series the average concentrations are given below:

^{238}U: 30-50 Bq kg^{-1} ^{232}Th: 40-60 Bq kg^{-1}

In Australia, the average annual dose received from this natural background radiation by an adult is approximately 1.5 - 2 millisievert (mSv), comprising approximately 0.3 mSv due to terrestrial gamma radiation, approximately 0.3 mSv due to cosmic radiation (at sea-level), approximately 0.2 - 0.25 mSv due to beta and gamma radiation from ^{40}K inside the body, and approximately 0.6 - 1.1 mSv due to inhalation of radon (^{222}Rn) and its radioactive decay products. In some parts of the world the annual dose received from natural background radiation exceeds 100 mSv, and in one known case 200 mSv. The local variability in annual background doses can be of the order of 0.5 mSv over distances of a few kilometres.

The widespread occurrence of NORM means that sands, clays, soils and rocks, and many of the ores and minerals (e.g. coal, oil and gas, bauxite, phosphate rock, ores containing tin, tantalum, niobium, rare earths, and some copper and gold deposits), commodities (e.g. water, building materials, fertiliser), products (e.g. ceramics), by-products (e.g. phosphogypsum), recycled residues (e.g. fly ash from coal burning, red mud from alumina production and slags from mineral processing), and devices used by humans (e.g. welding rods, gas mantles and electronic components) can contain NORM. Although the concentration of NORM in most natural substances is low, almost any operation in which any material is extracted from the earth and processed can concentrate NORM in product, by-product or waste (residue) streams. In some situations, specific radionuclides can become separated from the original radionuclide mixture (e.g. volatilisation of polonium and lead isotopes in mineral smelters or coal-burning power stations, and the separation of radium and uranium during the processing of phosphate ore to produce fertiliser and phosphogypsum).

Current and historical options for disposing of NORM wastes and residues on-site include landfill, down-hole disposal, near-surface disposal, land contouring, and disposal into mine tailings dams. Off-site options include dilution in industrial waste disposal facilities, land farming by ploughing in over a gazetted disposal area, incorporation into concrete for building construction or road base, and incorporation into other building materials such as bricks or plasterboard. In some cases, a lack of awareness of NORM issues in the past has led to the creation of contaminated sites for which no individual or organisation is legally accountable. The remediation of these sites will require careful consideration.

An important issue with NORM is one of awareness. In some industries the management of possible NORM exposures is already being addressed. However, in industries where NORM has not been recognised as a potential issue, occupational and public health matters may not be adequately addressed. Public health issues may also arise from the use of products containing NORM or from the inappropriate disposal of NORM bearing wastes.

Raising the awareness of both industries and the public, while keeping potential risks in context, is an important part of any NORM management strategy.

In most NORM industries the potential for a catastrophic radiological accident does not exist; hence any proposed precautions in NORM industries may need to be based only on control of radiation exposures.

Despite the widespread occurrence of NORM, and notwithstanding the development of guidance material in some countries and by international authorities, there is no systematic international approach to regulating NORM in commodities and products, or for the management of NORM residues and wastes.

Similarly, in Australia, there is no uniform regulatory approach to NORM issues. Each State and Territory and the Commonwealth Government has a regulatory system for radiation protection, including the use of radioactive materials. In each jurisdiction the regulations include exemption limits for the activity and activity concentration of radioactive material to be regulated. While all jurisdictions have regulations that deal with radioactive wastes in general, there is no uniform approach to regulation of NORM wastes and residues, and no national guidance on the management of these wastes. ARPANSA's role is to provide national guidance on the management of materials containing NORM, and promote the development of a uniform approach to the regulation of these materials.

REFERENCES

Cooper, M.B. (2003) *Naturally Occurring Radioactive Materials (NORM) in Australian Industries – Review of Current Inventories and Future Generation*.

Eisenbud, M. (1987) *Environmental Radioactivity: from Natural, Industrial and Military Sources.* Academic Press, Inc. Third Edition.

Radiation Health and Safety Advisory Council (RHSAC). (2003). *Naturally-Occurring Radioactive Material (NORM) in Australia: Issues for Discussion.*

3. OBJECTIVE

The aim of this document is to give guidance to regulators and to industries involving NORM about how to apply the framework for management of NORM arising from the *National Directory for Radiation Protection* (edition 2) and the *Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Minerals Processing.*

4. POSSIBLE OPTIONS

(a) Status quo – not produce any guidance on NORM;

(b) Industry develop mechanisms for self-regulation of NORM exposures;

(c) ARPANSA develop national guidance, including uniform exclusion and exemption criteria, treatment and disposal of NORM arising from various waste process streams and remediation of contaminated sites, in consultation with State and Territory regulators and industry;

(d) Develop a graded regulatory approach based on risk and incorporating uniform exclusion and exemption criteria.

5. IDENTIFYING AFFECTED PARTIES

Parties likely to be affected by the proposal include industries handling NORM, including the oil and gas production industry etc; State and Commonwealth Government radiation regulators, and the public.

6. POTENTIAL IMPACTS

- Costs to industry associated with actions leading to loss of business, eg denial of shipment or boycotting of products due to perception that risk is high;
- Compliance costs to a wide range of industries resulting from material being classified as "radioactive", and thereby being regulated, if exemption and exclusion limits are too low;
- Costs to industry and government of remediating abandoned and legacy sites;

- Costs to industry associated with public perception that risk from material classified as "radioactive" is high;
- Costs to industry, employees and the public associated with health impact resulting from underestimating risk in specific situations;
- Costs to industry and the public associated with environmental impact resulting from underestimating risk in specific situations;
- Costs to industry, employees and the public associated with inappropriate recycling of material containing NORM;
- Costs to industry, employees and the public associated with inappropriate use of material containing NORM in products.

Impacts can be optimised by adoption of cost-effective risk-based strategies by both regulators and industry.

7. PURPOSE and SCOPE

The Safety Guide will describe the broad regulator decision-making framework of exclusion and exemption established by the *National Directory for Radiation Protection* and the regulatory framework of the *Code*, giving broad guidance about how relevant decisions should be made to apply these frameworks. Specific industry annexes will address etc. The annexes to be developed in the first instance are:

Annexe X: oil and gas production

In the oil and gas industry, elevated concentrations of the radium isotopes ^{226}Ra (from the ^{238}U series) and ^{228}Ra (from the ^{232}Th series), together with their radioactive progeny, are found in the produced formation water associated with the oil and gas. The relatively high solubility of radium and radium compounds in water under the high pressures and temperatures which exist in the geological oil- and gas-bearing formations is a possible reason for these elevated concentrations. The uranium and thorium compounds that are the parents of the decay series generally remain in the underground reservoir. When the oil and/or gas and water are pumped or forced to the surface, the pressure and temperature drop to normal (environmental) values. This causes the radium isotopes to come out of solution and plate out on to the interior surfaces of pipes, valves, etc., and also on to the surfaces of sand particles that are suspended in the water. Radon separates from its parent radium and concentrates in the oil and gas. Radon decay products also plate out on the interior surface of pipes, valves, heat exchangers and other equipment. These processes result in the formation of scales and sand sludges containing elevated concentrations of radium isotopes and ^{210}Pb. These materials constitute a major component of the NORM wastes that are the subject of this work. The cleaning of contaminated surfaces in pipes and in or on other equipment with abrasive materials produces waste abrasives containing NORM. The handling of these materials during cleaning operations, and the replacement of pipes, etc., leads to the contamination of protective clothing worn by plant personnel during these operations.

Oil and gas production results in the accumulation of relatively small (tens to hundreds of tonnes per year) of wastes containing elevated concentrations of radium isotopes and their radioactive progeny. The radionuclide concentrations can vary markedly from one field to another. A study by ARPANSA assuming a concentration of 10 Bq g^{-1} for each radium isotope concluded that near surface burial of such waste material beneath 5 metres of clean fill would allow subsequent use of the land for most purposes.

Annexe Y: bauxite processing

In alumina production, the main solid residues are undissolved bauxite residues containing iron, silica and titanium. These residues, termed "red mud", are produced in large quantities and tend to contain elevated levels of thorium-232. Disposal of red mud and other solid residues commonly takes place by spreading in layers over a large area to allow the material to dry prior to rehabilitation by covering the waste with sand and revegetating the surface. Alumina smelting does not produce substantial quantities of solid waste.

Liquid residues arising from the washing of solid waste, and from settling ponds, are recycled as process water. Leachates from the disposal areas are collected and returned to production as process water.

Virtually all the radioactivity is transferred to the solid waste, and little, if any, of the radioactivity is present in the alumina.

Annexe Z: the phosphate industry

In phosphate ore processing, sulphuric acid is added to phosphate ore to produce phosphoric acid and gypsum (phosphogypsum). The phosphoric acid is used to produce fertiliser. NORM is found in tailings from fertiliser production that are normally used as backfill at the mine site, and the uranium from the ore tends to remain in fertiliser product; NORM levels in fertiliser do not cause any significant increase in the uranium and thorium levels of soils treated with fertiliser. In phosphoric acid production, most of the radium is left in the phosphogypsum, which can be stockpiled on site or disposed of as landfill. Phosphogypsum may also be used in fertiliser, soil conditioner, building material (eg plasterboard, cement aggregate), and in road construction.

8. RELATIONSHIPS

The Code and Guide will make use of the fundamental requirements and guidance spelled out in RPS1, the *National Directory (RPS 6)* and the *Mining Code (RPS9).*

Refer to DS 352, RS-G-1.7, other IAEA publications; the ICRP Recommendations; and other stuff.

9. CONTENT

The following is an example of the possible content of the Safety Guide:

INTRODUCTION
- What is NORM?
- What is different about NORM?
- Industries which handle materials containing NORM
  - *Phosphate*
  - *Oil and gas*
  - *Coal*
  - *Bauxite*
  - *Mineral sands (rare earths)*
- Current regulatory requirements

STAGES IN HANDLING OF MATERIALS CONTAINING NORM

Mineral extraction *(uranium, mineral sands, bauxite, gold, copper, oil and gas, coal, tin,….)*
Processing *(products, by-products, residues, wastes)*
Transport of bulk commodities, residues and wastes
Use of products
Recycling of residues
Management of wastes

RADIOLOGICAL ISSUES

General
Exposure pathways *(inhalation, ingestion, external exposures)*
Mineral extraction
Processing *(products, by-products, residues, wastes)*
Use of products
Recycling of residues
Management of wastes

REGULATORY ISSUES

Current situation *(the National Directory for Radiation Protection, the mining code, the near surface code, transport regulations)*
International developments (*RS-G-1.7, DS-352*)
Application of Exclusion and Exemption to NORM
Graded Approach (*risk based, impact assessment,)*

SUMMARY AND DISCUSSION

ANNEXES

Examples of assessments for specific industries
Oil and Gas - disequilibrium
Phosphate (fertiliser, phosphogypsum) – disequilibrium
Bauxite (red mud) – thorium
Metal processing
Coal (fly ash)
Iron and Steel (slag)
Rare earths
Scrap metal recycling

10. SUGGESTED DRAFTING GROUP REPRESENTATION

To be determined

11. PRODUCTION

Provisional schedule:

Approval
Adoption of DPP: RHC October 2006

Development
Drafting Group to be formed November 2006.
Drafting Group members:
First draft by November 2007.
Provisional public comment draft by March 2008.

Review

RHC review of provisional draft:March 2008.

Consultation and regulatory impact assessment

March-July 2008

Endorsement

Review by RHC of final draft: October 2008

Endorsement by RHSAC: December 2008