Introduction and Scene Setting

P.V. Shaw[1] and C. Lefaure[2]

[1] *Radiation Protection Division, Health Protection Agency, Leeds, UK*
[2] *CEPN, Fontenay aux Roses, France*

1. Abstract

This is the 9th workshop organised by the EAN, and the subject is the optimisation of worker exposures from natural radiation sources. Specifically, the following sources are considered:

- **NORM** (Naturally Occurring Radioactive Materials) – the term used to describe minerals and other materials that contain radionuclides of natural origin from the uranium-238 and thorium-232 decay series, causing a significant increase in the exposure of workers or members of the public, which cannot be disregarded from the radiation protection point of view. Such materials include those arising from mineral processing operations in which the concentrations of naturally occurring radionuclides have been technologically enhanced (sometimes referred to as TENORM); and

- **Radon**. Principally radon-222, but radon-220 (“thoron”) is also included in the scope.

Another significant type of natural radiation exposure is from ***cosmic rays***, for example, as received by aircrew. A separate presentation on this source of exposure is given in the introductory session to this workshop. However, because of the limited scope for implementing ALARA, cosmic ray exposures are not a major subject in the remainder of the Workshop.

The trend established in previous workshops is continued, i.e. the focus is on participants working in groups, to discuss the issues raised by presentations, and to develop proposals for improving the implementation of radiation protection.

The objective of the workshop is to consider how the ALARA principle can be applied in practice to occupational exposures from radon and NORM. Specific questions arising from this objective are listed at the end of this presentation. First, however, to help set the scene, a short summary of the scale of exposures arising from these sources, and how they are regulated within the EU, is given below.

Marilee Williams, Editor
Proceedings of the 9th EAN ALARA Workshop
18-21 October 2005
Augsburg, Germany

2. Occupational exposures: workers and doses

2.1 NORM

Data on the number of persons in the EU working within NORM industries, and the doses received, were recently reviewed in the SMOPIE Project(1). In terms of the number of exposed workers, reliable data were scarce, and only approximate, order-of-magnitude, estimates were considered possible: these are shown in Table 1. The estimates do not cover all industrial processes that may involve significant exposures to NORM. Also, there are work activities listed for which no reasonable estimate of the number of exposed workers can be given. However, very approximately, a total of *100,000 workers* in the EU may be affected.

In terms of the doses received, there were even less reliable data. As such, only a broad indication of the doses involved could be obtained, as shown in Table 2.

Despite the limitations of the available data, it is still concluded that occupational exposures from NORM are widespread, and that doses can be significant if appropriate controls are not in place. Further work to establish the actual number of exposed NORM workers, and the doses received in practice, was recommended by the SMOPIE report.

2.2 Radon

Indoor radon levels have been extensively measured and mapped throughout Europe, although the majority of data relate to homes. Care is required when extrapolating such data to workplaces, which can be very different in terms of construction, size, shape and ventilation. In the UK, HPA (formerly NRPB) has analysed the sub-set of radon measurements from workplaces, and from this has produced the following national estimates:

- 10, 000 workplaces in UK above radon action level (400 Bq/m^3)
- 100 – 150 thousand workers potentially exposed above action level
- Of these, a few % (= a few thousand) workers receiving > 6 mSv/y

Attempts have been made to obtain similar estimates from other European countries via the various representatives within the EAN. A summary of the results is shown in Table 3, and this demonstrates that there is generally a lack of such information. A very simple extrapolation of the UK data to the EU as a whole produces a total of *one million exposed workers*. Although this is a very rough estimate, it does demonstrate that a large number of European workplaces and employees could potentially be affected. The lack of data on this (especially when compared to exposures from artificial sources) is somewhat surprising.

Table 1. SMOPIE Project estimates of the number of potentially exposed workers in EU NORM industries.

NORM industry and work activity	**Number of exposed workers (rounded)**	**Basis for estimate**
Thoriated electrodes, production, grinding and use	70 000	Extrapolation of Dutch and German data
Phosphate fertiliser trade and use	10 000	German data multiplied by 4
Oil and gas production, exposure to scale dust at maintenance	2 000	Based on 1000 production installations and two workers potentially exposed annually per installation
Zircon sands, milling and processing	500	UK and German estimate multiplied by 5 for European Union
Rare earth extraction industry, (Y, Ce, Eu, La, etc.)	400	Based on French data, multiplied by 3 for other producers
Cement production, maintenance of clinker ovens	300	Based on 60 cement production plants and 5 exposed workers per plant
Coal-fired power plants, Maintenance of boilers	100	Based on 70 plants and 2 exposed workers per plant annually
Phosphoric acid production, scale removal	100	Ten plants producing phosphoric acid from phosphate rock. Ten exposed workers per plant.
Primary iron production, exposure to sinter dust	100	Based on 7.4 million tonnes total annual EU blast furnace primary iron production in 20 plants. Five exposed workers per plant
TiO_2 pigment, solid waste and Ra-scale	80	Based on 16 production plants, sulphuric acid and chloride process. Five exposed workers per plant.
Rare earth catalyst production, maintenance, scales	20	Largely replaced by much cleaner “concentrates” as raw material. Assumed number of plants 10, and two exposed workers per plant
Thermal phosphorus production	20	Based on Thermphos input into SMOPIE, one plant
Lead/zinc smelters	20	Number of plants 20 and 1 exposed worker per plant
Tantalum, niobium extraction from ores or slags	Not known	Number of plants at least 1.
Ground water treatment, scales and sludges	Not known	
Residues from past industrial activities	Not known	
Total (rounded)	**85 000**	

Table 2. SMOPIE Project summary of data on dose ranges associated with NORM work activities.

Potential annual dose from inhalation (mSv)	Type of NORM industry
Above 20 mSv	Rare earth processing (a few workers)
From 6 to 20 mSv	Grinding of thoriated electrodes Zircon milling (a few workers)
Below 6 mSv	All other NORM industries

Table 3. Summary of information on radon in workplaces.

Country	Estimated number of workplaces above action level[1]	Estimated number of employees affected (thousands)	Estimated number of employees with doses >6 mSv/y
Austria	No information		
Belgium	No information		
Croatia	< 20	A small number	<10
Czech Rep[2]	Unknown (see footnote)	Unknown (see footnote)	
Denmark	Unknown but thought to be a small number	Unknown but thought to be a small number	
Finland[3]	Unknown but thought to be very small	Unknown but thought to be very small	
France	Unknown	Unknown	
Germany	No information		
Greece	No information		
Rep of Ireland	8% [4]	Less than 40-50[5]	Less than about 1500[6]
Italy	No information		
Netherlands	Unknown but probably close to zero	Unknown but probably a very small number	Unknown but probably zero
Norway	No information		
Spain	No information		
Sweden	No information		
Switzerland[7]	Unknown	Unknown	
UK	10, 000	100 - 150	Few thousand

[1] National action levels are shown in Table 4.
[2] Measurements are being made in many workplaces (especially water companies), but the results are no available at this time. The only results available so far are for underground caves, in which the radon concentration exceeds 1000 Bq/m^3 in 12 workplaces. There are approximately 100 full time workers, estimated effective doses are typically 2-3mSv/y, with a maximum of 8 mSv/y.
[3] A combined home/work survey indicated that radon levels in workplaces were on average 30 Bq/m^3: three times lower than in homes. The highest value measured in a workplace was 474 Bq/m^3.
[4] The estimate of 8% is derived from data from 3800 schools - 8% had levels > 400 Bq/m3. The geographical distribution of schools is similar to workplaces, and 8% is the best estimate at this time. However it is likely to be an overestimate as schools are generally one story buildings whereas many other workplaces are on upper floors of buildings.
[5] This figure is very approximate and was arrived at by applying data for homes >400 Bq/m^3 directly to the workforce. Workers in outdoor occupations such as agriculture, fisheries, construction and transportation were not included. This figure is probably an over estimate because of increased ventilation in workplaces and the fact that many workplaces are on the upper floors of buildings
[6] This figure is derived from schools data, assuming that working in a radon concentration of 800 Bq/m^3 may give rise to a dose of 6mSv. 3% of schools fell into this category - this translates into a figure of 1500 workers. Again this is likely to be an overestimate.
[7] Measurements do exist, but not in all critical sites (e,g,water companies). In tunnel and underground military plants radon concentrations exceeded 3000 Bq/m^3

3. Regulation and optimisation of exposures from natural sources

Information on the regulation of work activities involving exposure to natural sources was collated as part of an earlier EC study[2]. A summary of some of this information (reviewed and updated, where appropriate, by members of the EAN) is reproduced in Table 4. While there are national differences, these are not especially large. Specifically, the use of a 1 mSv/y application level for occupational NORM exposures has been widely adopted.

Including natural sources within the scope of national regulations does not necessarily mean that exposures are subject to the ALARA principle, i.e. as is applied to artificial sources. The application/action levels shown in Table 4 are effectively “cut off” levels, below which regulations (and hence optimisation) do not apply. Even above these levels, the optimisation of exposures cannot be assumed. As noted by the SMOPIE report, and in previous Workshops, many NORM industries have only recently become aware of the need for radiological controls. Consequently, they have not benefited from “ALARA in design” considerations, and the concept of “ALARA in operation” has yet to be fully developed. They have, however, typically been subject to practical controls based on industrial hygiene requirements. The interface between these controls and the development of the ALARA principle is a subject for this workshop to consider.

In the case of radon in the workplace, the application of the ALARA principle is not widespread. In terms of EC guidance[3], radon in workplaces is dealt with using an Action Level approach based on the principles of intervention and focused on radon concentrations. If radon concentrations are found to be below the Action Level, there is no requirement for further action other than re-testing in certain circumstances. The use of ALARA to further reduce exposures is not a requirement (although it may sometimes be considered appropriate where the radon concentrations approach the Action Level). If the radon concentrations are found to be above the Action Level, remedial action is required to substantially reduce the radon concentrations. Although this remedial action should, in terms of the requirements for intervention, be optimised, it is only when the radon concentrations still remain above the Action Level that the requirements for practices (including ALARA on an ongoing basis) become applicable. In most above ground workplaces, relatively simple and inexpensive remedial measures will be successful in getting below the Action Level[3].

The requirement for ongoing ALARA would therefore seem to be limited essentially to certain underground workplaces where it might prove difficult to achieve sufficient reductions in radon concentrations through remedial action. However, it might be argued that this Action Level approach, which is focused only on radon concentrations, is not the only approach that should be considered. In some situations, a better option might be to adopt a “practice” type of approach from the outset, thus opening up possibilities other than simply reducing radon concentrations, for instance minimising the exposure time. If this is true, than the existing guidance on the approach to radon in workplaces perhaps need to be reviewed and expanded. This is a topic for this workshop to consider.

Table 4. Summary of regulations and application criteria for occupational exposures from natural sources.

Country	Title of regulations	Basis of Application	
		NORM	Radon
Austria	Radiation Protection Act (BGBl. I Nr. 146, Strahlenschutz-EU-Anpassungsgesetz 2002), 20th August 2002. Radiation Protection Ordinance (draft)	?	None
Belgium	Royal Decision of 20th July 2001 (ARBIS)	1 mSv/y	3 mSv/y or 800 kBq m^{-3} h^{-1}
Croatia	Regulations on the limits of exposure of workers and population, action and intervention levels (Official Gazette no. 108/99), 20. October 1999.	1 mSv/y	1000 Bq/m^3
Czech Rep	Act No. 18/1997 Coll. on Peaceful Utilisation of Nuclear Energy and Ionising Radiation (the Atomic Act) and on Amendments and Additions to Related Acts Decree of the SÚJB No. 307/2002 Coll. On Radiation Protection	1mSv/y	1000 Bq/m^3
Denmark	Radiation Law, Law No 94 31st March 1953 as modified by Law No 369 6th June 1991. Ministry of the Interior and Health Order No 192 of 2nd April 2002 on exemption from law on the use of radioactive substances (Order 192)	Based on activity concentrations	400 Bq/m^3
Finland	Radiation Act (592/1991) as amended by 1142/1998 Radiation Decree (1512/1991) as amended 1142/1998 ST 12.1 Radiation Safety in Practices Causing Exposure to Natural Radiation ST 12.2 Radiation of Construction Materials, Fuel Peat and Peat Ash ST 12.3 Radioactivity of Household Water	1 mSv/y	400 Bq/m^3
France	Ordinance No. 2001-270 of 28th March 2001 (FR 2001) Decree No. 2002-460 of 4th April 2002 (FR 2002) Decree No. 2003-296 of 31st March 2003 (FR 2003)	1 mSv/y	400 Bq/m^3
Germany	Radiation Protection Ordinance (Strahlenschutzverordnung), 20th July 2001 (RPO) Nuclear Law (Atomgesetz) 3rd May 2000.	According to work activities	2000 kBq m^{-3} h^{-1}
Greece	Radiation Protection Regulations Joint Ministerial Order No 1014 (Ö OP) 94, Official Gazette No 216B, 06/03/01 (RPR).	1 mSv/y	400 Bq/m^3
Rep of Ireland	Radiological Protection Act, 1991 (Ionising Radiation) Order 2000 (S.I. No 125 of 2000)	1 mSv/y	400 Bq/m^3
Italy	Legislative Decree no. 230 of 17th March 1995 Legislative Decree no. 241 of 26th May 2000 (modifying Decree no. 230) Legislative Decree no. 257 of 9th May 2001 (modifying Decree no. 241)	1 mSv/y (0.3 mSv/y for public)	500 Bq/m^3
Netherlands	Royal Decision of 16th July 2001 (BS).	1 mSv/y	None
Norway	Radiation Protection Act, 12 May 2000 Regulations on radiation protection and use of radiation sources, 23 November 2003	1 mSv/y	1000 Bq/m^3 (underground) 200 Bq/m^3 (above ground)
Spain	Royal Decree 783/2001 on the Health Protection against Ionising Radiation (RD)	Based on work activities	None
Sweden	Radiation Protection Act (1988/220) Radiation Protection Ordinance (1988/293) as amended 1st Sept 2001	?	400 Bq/m^3
Switzerland	Swiss Legislation on Radiological Protection http://www.bag.admin.ch/strahlen/lois/pdf/SR_814_501_en.pdf	No limit for uncontrollable sources	3000 Bq/m^3 2000 h/y (20 mSv)
UK	The Ionising Radiations Regulations 1999	1 mSv/y	400 Bq/m^3

4. Objectives of the workshop

The main objective of the workshop is to consider how the ALARA principle can best be applied to occupational exposures from NORM and radon. The Workshop Programme Committee identified two main themes that emerge from this objective, i.e.:

- How can the commitment to radiation protection (in terms of employers, employees, regulators and other stakeholders) be encouraged and increased?
- How should exposure management be implemented in practice?

Four topics have been selected for the working groups, each of which is intended to contribute to the above objectives. To assist in this process, the Programme Committee produced a series of questions that these groups might like to consider, as follows:

4.1 Types of regulation and the optimisation of protection

- What type of regulatory system is most appropriate?
- What are the most appropriate criteria for determining when regulations do/do not apply?
- What should the regulations require? What are the most important requirements for NORM and radon? Should these be similar to the requirements for artificial sources?
- What should be required in respect of the ALARA principle?

4.2 Communication and stakeholder involvement

- How should the radiation risks and the need for controls be communicated?
- How can employers be encouraged to implement protection measures and the ALARA principle?
- What is the role of employees? Can/should this role be increased?
- What other stakeholders are there? How should they be involved?

4.3 Practical management of radon exposures

4.4 Practical management of NORM exposures

Essentially, the same questions apply to both these topics, i.e.:

- What methods should be used to identify exposure situations, and to assess the associated risk?
- What monitoring tools, methods and strategies are most effective in terms of helping to manage exposures?

- What does practical experience tell us, i.e. in terms of the best ways to manage and optimise exposures?

- Are there lessons to be learnt from comparing the approaches to NORM and to radon? How do these approaches interface with existing workplace safety and industrial hygiene regimes?

As discussed above, the Action Level approach to the management of radon exposures implies some important differences (and questions) with respect to the role of ALARA. The above questions reflect some of the issues raised by the programme committee. They are just suggestions for starting the group discussions. The objective of the working groups is to produce recommendations, and to identify which stakeholders these should be addressed to. The final session of the workshop will be devoted to the collation and discussion of these recommendations.

5. References

1. NRG Report 20790/04.60901/P. "Strategies and Methods for Optimisation of Protection against Internal Exposure of Workers from Industrial Natural Sources (SMOPIE)". Final report of the SMOPIE Project carried out under contract No. FIGM-CT2001-00176 by order of the European Commission (2004).

2. European Commission. Radiation Protection 135. "Effluent and dose control from European Union NORM industries. Assessment of current situation and proposal for a harmonised Community approach" (2003). Available from http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

3. European Commission. Radiation Protection 88. "Recommendations for the implementation of Title VII of the European Basic Safety Standards Directive (BSS) concerning significant increase in exposure to natural radiation sources" (1997). Available from http://europa.eu.int/comm/ energy/nuclear/radioprotection/index_en.htm