NORM in Western Australia – plenty of mineral but not enough human resources

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Abstract

The paper provides an overview of Western Australian industries dealing with NORM – such as mining, separation and downstream processing of titanium and zirconium minerals, rare earth mining and processing, the development of lithium-tantalum ore deposits and of other facilities where NORM requires attention from occupational and environmental radiation protection perspectives.

Brief descriptions of the Western Australian resources industry and the regulatory system are provided, specifically describing a memorandum of understanding between two main government departments that was developed to prevent regulatory overlaps.

The requirements for site radiation safety officers (RSO), such as necessary training, qualifications and experience are discussed from a regulatory point of view. The information on the application of these requirements in practice at different sites is also provided.

Additional issues are discussed, such as the fact that there are no full-time RSO's in Western Australia. All of them have other, primary, roles – such as laboratory supervisor, metallurgist, environmental or OHS advisor and so on. The examples of problems associated with this fact are provided. The measures to prevent a radiation protection consultant becoming an RSO for more sites that is reasonably possible are also described.

Details are provided on the training and mentoring of potential future RSO's –

- From a historical perspective,
- Arrangements that are used at the present time, and
- Possibilities in the future.

Lastly, a comparison is made between the training requirements applicable for Radiation Safety Officers dealing with NORM in Western Australia and the requirements detailed in the IAEA Publications.

1. Introduction

1.1. Western Australia

Western Australia (WA) is the largest Australian State, with an area of over 2.5 million km² (almost 1 million square miles).

The population of the State is approximately 2.6 million people, 92% of which live in the capital Perth and in the South-West corner of the State. The remaining territory is very sparsely populated and in order to illustrate the density of population north of Perth a different measure is used: km²/person instead of number of people per km^2. This value is typically around 7-9 km²/person, but may be over 40 km²/person in some areas.

1.2. Western Australian mining industry

The mining and mineral processing industry directly employs over 113,000 people, which is almost 50% of the total mining workforce in Australia and close to 10% of total WA workforce. The industry (including petroleum and natural gas) accounts for 85% of the State's and 41% of Australia's income from exports.

There are more than 130 large mining projects, but also several hundreds of smaller mines. Most of the mining and processing sites are located in remote areas, travel to which may take 6 to 8 hours.

Many different mineral resources are exploited and processed in Western Australia: iron, petroleum, gas, gold, aluminium, nickel, cobalt, copper, lead, zinc, titanium, zirconium, lithium, tantalum, coal, salt, diamonds, manganese, vanadium, rare earths, palladium, platinum, silver, tin, talc, gypsum, phosphate, and there are also several prospective uranium projects (the Geological Survey of Western Australia identified over 60 potential commercially viable uranium deposits).

At almost all mining sites industrial radiography equipment such as density and/or level gauges containing ^{137}Cs are used for process control purposes. There are also many portable gauges at mining sites (principally for moisture content measurements) and, additionally, X-ray equipment is routinely used in both process control (X-ray machines in mine site laboratories) and in mineral exploration (portable X-ray mineral analysers).
Licensing for the radiation-emitting equipment is handled by the State Radiological Council (Radiation Health Branch of the Health Department) and in order to become a 'Radiation Safety Officer' (RSO) for this equipment a candidate typically needs to attend a short (one to three days) training course and successfully pass the appropriate Radiological Council examination.

The situation with radiation protection in mining and processing of naturally occurring radioactive materials (NORM) is much more complex. Generally, a "graded approach" principle is used in the management of radiation safety at mine sites:

- At some operations radiation exposures of workers and the associated impact on the environment are sufficiently low and typically do not require an appointment of the RSO for NORM. Examples of these situations are mining and processing of lithium, aluminium and nickel, where only an initial assessment of radiation exposures and impacts is carried out and, following application to the State mining engineer, the sites are exempted from the radiation protection regulations.
- At other operations radiation management is required, radiation monitoring and management programmes are in place and the RSO for NORM is appointed. This is the case of mining and processing operations dealing with titanium, zirconium, tantalum and rare earth minerals.
- It is important to note that even if a radiation management appears not to be required for a particular mineral type, the assessment of the radiation protection requirements in many cases may still need to be carried out.
  In almost all cases if it was demonstrated that there is no NORM (as per its definition) on a mining site, the radiation protection regulations are not applicable. In some cases, however, unexpected (and very high) concentrations of uranium have been discovered in the ground water, indicating potential presence of a uranium resource; thus specific measures are implemented to prevent or limit the use of such water for the purpose of dust suppression on mine roads. Another example of such situation is comparatively high concentrations of ^{40}K and ^{87}Rb in lithium ores and concentrates, discovered at some locations. However, however as the radiation dose implications from these radionuclides are very low, an exemption is typically granted.

2. Requirements for the radiation safety officer (RSO)

2.1. Regulatory perspective

From the regulatory point of view, several different WA Government departments are administering different (and sometimes conflicting) regulations in regards to radiation protection in mining and mineral processing: Department of Mines, Industry Regulation and Safety (DMIRS), Department of Health (DoH) through the Radiological Council, and Department of Water and Environmental Regulation (DWER).

A Memorandum of Understanding (MoU) exists between DMIRS and the Radiological Council to minimise potential overlap or duplication of regulatory responsibilities in relation to radiation safety for mining operations [1]. In accordance with this document the nominee for the position of RSO must have appropriate qualifications and experience acceptable to both the DMIRS and the Radiological Council and must be approved by both agencies. In most cases, approval is provided by the State mining engineer (in the first instance) who advises the Radiological Council, and (in most cases) the appointment is endorsed by the Radiological Council.

The requirements for the radiation safety officer qualifications and experience were first formalised in the guideline of the Chamber of Minerals and Energy of WA in July 1997 [2]. These requirements remained mostly unchanged and are detailed in one of the current DMIRS NORM Guidelines [3]:

(a) *Education*: minimum of a Bachelor degree in a technical discipline (preferably in physics, chemistry or engineering);

(b) *Training*: successful completion of the surface ventilation officer course, of the fixed radiation gauges course, and of an "appropriate advanced course in radiation protection in mining and mineral processing".
(c) *Knowledge*: an employment history in mining and/or processing industry and a clear understanding of mining and mineral processing principles, particularly those that are applied at the particular operation, practical experience in radiation safety in mining for a minimum of 12 months under the general direction of an approved RSO, as a technician or a specialist (the requirements in the 1997 CME guideline was two years).

2.2. The work of a mining/processing RSO in Western Australia

At the current time there is not a single mining and processing site in Western Australia, where the RSO is a full time position, which creates numerous problems, for both the companies that appoint RSO's and for the Government departments that approve these appointments.

Radiation protection is a small and often forgotten part of the other *primary* job of the statutory RSO (who typically is a laboratory supervisor, OHS specialist, environmental adviser, processing metallurgist and so on). As a result, there has been a significant decline in the knowledge, skills and experience of this specialist requirement in the State's mining industry.

A personal example of a part-time RSO work can be presented:

- Primary mining and mineral processing site (titanium, zirconium and rare earth minerals): safety officer (inspections, audits and inductions of new workers), ventilation and noise officer (dust and noise monitoring and assessment), occupational hygienist (heat stress, chemicals, biological hazards, ergonomics, etc.), radiation safety officer (fixed gauges, X-ray equipment and NORM in mining and mineral processing). Also participation in numerous other activities and training on and off-site.
- Six more sites (mines, processing plants, ports, mineral storage) – radiation safety officer. Driving between all sites was approximately 3,000 kilometres every month.

In many cases appointed RSO's are not aware of the statutory responsibilities of the position and their personal legal liabilities; and sometimes the appointed RSO's demonstrate a lack of understanding of even basic radiation protection principles.

There are not many radiation protection consultants with mining industry experience in Australia. Those RSO's who are consulting mainly have a background in academia, laboratory or government and typically have only a theoretical or limited knowledge of the mining industry.

In some cases companies choose to appoint a consultant to be an appointed Radiation Safety Officer, either for the duration of operations or to train company personnel within an agreed time period. In this case the use of the specific IAEA Safety Guide [4] is recommended, but unfortunately the document is almost never used.

When a company appoints a consultant as an RSO, DMIRS always requires information on how much time a person is going to spend working for a specific company:

- To ensure that sufficient resources are allocated for radiation protection for the particular site, and
- To confirm that no consultant is proposing to work for different companies for more time that is physically possible.

Despite the fact that the appropriately educated and very experienced personnel are employed in relevant WA Government departments, there is simply too much other work that these people need to carry out, very often at the expense of inspecting and regulating radiation safety in mining and mineral processing.

There is also a significant lack of professionals elsewhere in the world, and it is unlikely that the Western Australian mining industry or Government departments will be able to attract a suitable number of qualified people from overseas. Those overseas specialists that could be recruited will not only need to be fully conversant with relevant Australian and WA regulations and guidelines before they commence their work, but will also require to have a thorough understanding of the specifics and culture of the WA mining industry.

3. Training of radiation safety officers

3.1. Advanced training courses: past

In the past there were several advanced radiation protection training courses available to the mining industry in Australia, none of which were based in Western Australia.

In 1987 Australian Radiation Laboratory (ARL) in Melbourne, which is now a part of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) had developed a very comprehensive training course, Radiation Protection in the Mining and Milling of Radioactive Ores [5]. This training was available until mid-1990's.

Since early 1990s an advanced radiation protection course was available from the Australian Nuclear Science and Technology Organisation (ANSTO) in Sydney. However, in mid-1990s the contents and duration of the course had been halved to five days and only 4 hours were dedicated to mining, until early 2000's. This training course is still available [6], but it is intended for the broad range of industries (including working with X-ray equipment, sealed sources, fixed gauges, shielding, source security, etc.) and thus may not be entirely suitable for the training of radiation safety officers for mining and mineral processing industry. Additionally, it appears to be hard to ascertain at the current stage what, if any, experience in mining in mineral processing the developers and the presenters of this course have.

In late 1990's another advanced training course was developed by a consultancy Radiation Advice and Solutions [7] in Queensland. This training is available in infrequent intervals (perhaps once per year in WA) and remains the only advanced training course available to the industry at the current time.

Several training courses were also prepared by different consulting firms. However, to the best of the author's knowledge, none of these courses were developed and presented by people with work history in the mining and mineral processing industry. The contents of some of these courses were reviewed and the lack of expertise and understanding of the mining industry was clearly evident. It is, therefore, not considered worthwhile to mention these courses in this paper.

3.2. Government Skills Australia training units

In the late 2000's the Australian Federal Government commenced an initiative to develop competency units for radiation protection. The contents for ten units of competence was eventually developed, for the delivery by suitable "registered training organisations" (RTO's). An RTO needs to comply with strict requirements in order to be able to conduct the training, however, the reward is that training courses may be recognised Australia-wide, and could lead to a nationally recognised qualification.

Despite extensive consultations with representatives from the mining and mineral processing industry and Government departments in WA, no comments were taken into account, with the result that the units of competence are generic and are not fit-for-purpose for application to the mining and mineral processing industry. Only one introductory unit of competence has been effectively delivered, by two RTO's – the remaining nine units have proven, over the passage of time, to be of no practical use.

At the current time it appears impossible to determine who (if anyone) may be available to amend those units if required, and only five of the ten units (without any descriptions) are listed on the internet site of the Australian Department of Employment, Skills, Small and Family Business [8].

The bureaucratic burden to comply with the general RTO requirements is enormous, as the development of the induction level course several years ago has clearly demonstrated. Only 10% of the total time required for the development of training materials was spent on the preparation of lectures and exercises and 90% of the time on the course official accreditation:

- "Mapping" of the course: linking the contents with each and every line listed in the relevant unit on official forms, and
- Completing numerous and voluminous submissions to different government departments that deal with training in general (and, thus, have no understanding of industry specifics).

Additionally, only an RTO is allowed to deliver training to the national competency standards. The RTO registration is quite expensive and the time and cost of regular compliance audits of the required quality control systems are unaffordable for most of the potential course providers. It was estimated that the cost of the development of an advanced training course for a Registered Training Organisation would reach AU$500,000 before any fees can be collected from the participants.

3.3. Recent developments

In the mid-2010's ANSTO has commenced the development of a 'mining' radiation safety course. It is not clear if this work continues or it was partially incorporated into the general training course referred to in part 3.1. Regardless of the outcome of the development process, it is concluded that a suitable course is unlikley to being offered by ANSTO at the current time.

In 2014 and 2018 two universities (one in South Australia and one in Western Australia) proposed to develop post-graduate courses in radiation protection, and it was planned that the course would most likely comprise of three post-graduate units and that each unit will be taught over one semester (13 weeks).
These proposals are very unlikely to succeed, as:

- An attendance of 12-15 persons is required for such training to make an economic sense, but not more than 2-3 candidates would be available at any given time.
- It is considered impossible that any mining professional in Western Australia would be able to have the extended time off-work to attend this training, especially as the RSO is always only a part-time position (as described in part 2.2).

Furthermore, similar to the ANSTO training course, the relevance of this proposed training to the mining and mineral processing industry is not currently known and it is not clear what, if any, experience in mining in mineral processing industry the developers and the presenters of such courses would have.

3.4. Current situation

There is definitely a need to increase the knowledge and competencies of radiation protection personnel, both in the mining and mineral processing industry and in the relevant Government departments – especially taking into account the possibility of several uranium mines operating in the State in the future.

Historically, the training of radiation safety officers in the minerals industry in Western Australia was undertaken along the lines of hands-on training.

In the mining industry one cannot become a haul truck driver or an excavator operator without actually getting training in operating that specific mining equipment and being supervised and guided by an experienced personnel before receiving an accreditation "ticket". The theoretical knowledge is mostly useless without the knowledge of its application in a real mining and/or processing environment.

However, in Western Australia there appears to be no requirement for a presenter of a training course for the mining industry to have any work history or actual experience in mining. The only paramount

requirement is a Certificate IV in Training and Assessment that can be obtained by anyone in two weeks. This fact led to many embarrassing situations where presenters reading from the prepared slides were unable to answer very simple questions.

In contrast, the process of preparation and delivery of training courses for the International Atomic Energy Agency (IAEA) Technical Cooperation programmes around the world is based on different criteria, emphasizing the need for the relevant work experience and knowledge of the presenter. These courses undergo a process of peer review by the relevant IAEA departments. Both developers and presenters of an international course are selected from the list of IAEA Experts qualified and experienced in a particular field of radiation protection – training or teaching qualifications are not considered to be the highest priority, let alone the only criterion to demonstrate the appropriate qualifications.

The mining and mineral processing in Western Australia remains the only branch of radiation protection where the requirements for the radiation safety personnel qualifications and employment history are not formalised in the State legislation (only a guideline exists):

- No one without relevant qualifications and experience can develop and conduct radiation protection training in areas such as industrial radiography or fluoroscopy;
- But there appear to be no barriers for a dentist or a university tutor to offer 'radiation protection in mining' advice and training – the only requirement is a two weeks course in "training and assessment".

The summary of the current situation is as follows:

1. Due to the fact that radiation is a very contentious issue, it is likely that in the future there would be class actions and claims for compensation for diseases allegedly caused by radiation, as well as for the radiological contamination of land and water. In these cases the avenue will be opened for involving both the Government departments and presently appointed radiation safety officers in these litigations and claims in the future.
2. Currently available and proposed advanced radiation protection training courses may not be suitable for the needs of Western Australian mining and mineral processing industry.
3. The development and official accreditation of both the Registered Training Organisation and the advanced training course by an independent provider is considered to be unrealistic.
4. There is an obvious need for the training to be carried out, not only on once-off basis, but also continuously – for the relevant personnel both in the industry and in the Government departments.

3.5. Radiation protection training for radiation safety officers in the future

An advanced radiation protection course for the mining and mineral processing industry is currently being developed by Calytrix Consulting. The proposed course will take one week and will contain:

- Thirty two lectures,
- Six practical tutorials (on the use of different radiation monitoring equipment),
- Six exercises (on the relevant calculations and the interpretation of data), and
- An exam (competency assessment).

All relevant Australian and International regulations, codes and guidelines will also be provided to the participants.

The materials will be based on:

- Industry experience in mining and processing of NORM worldwide,
- Western Australian legislation and Australian Standards, and
- National guidelines and technical documents where the information is not available in Australia: from the USA, Canada, European Union, South Africa, Brazil, Kazakhstan and Malaysia.

In the process of review of the contents of the training courses currently available to the Western Australian mining and mineral processing industry it was found that the IAEA Safety and Technical Reports and documents directly relevant to the mining and mineral processing industry are not even

referenced. This will be corrected in the development of this course and the material from IAEA documents [9–26] will be used in the preparation of training materials.

Other IAEA documents important for the training of radiation protection personnel also appear not be used, therefore a specific attention is being paid to the four relevant IAEA publications [27–30].

The most important consideration is:

- It should not be expected that the radiation safety officer at a mining and/or mineral processing site will remember the values for the dose conversion factors for the inhalation of 5 μm size dust containing ^{232}Th, or for the ingestion of water containing ^{226}Ra, or typical ^{220}Rn equilibrium factors. Neither there is a need to remember which are all necessary parts of a document such as an Environmental and/or Radiological Impact Assessment.
- It is deemed more important to ensure that the RSO:
    - Will know where to quickly find the necessary information, and then
    - Will know how to put the information to good and proper use at his/her site.
- RSO's must be competent and able to apply fundamental radiation protection principles to a range of diverse scenarios. They also need to understand their regulatory obligations and have ready access to technical information to support their role.

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