QGL 1

Guideline for management of Naturally Occurring Radioactive Material (NORM) in metalliferous mines

Mining and Quarrying Safety and Health Act 1999

July 2014, Version 1.0

Guideline – QGL 1

Management of NORM in metalliferous mines

This document is issued in accordance with Part 5 — Guidelines Sections 62 - 64, and Part 3 — Safety and health obligations Section 34(3) of the *Mining and Quarrying Safety and Health Act 1999.*

Part 5 – Guidelines

Section 62 Purpose of guidelines

A guideline may be made for safety and health stating ways to achieve an acceptable level of risk to persons arising out of operations.

Section 63 Guidelines

(1) The Minister may make guidelines.
(2) The Minister must notify the making of a guideline by gazette notice.
(3) The chief executive must keep a copy of each guideline and any document applied, adopted or incorporated by the guideline available for inspection, without charge, during normal business hours at each department office dealing with safety and health.
(4) The chief executive, on payment by a person of a reasonable fee decided by the chief executive, must give a copy of a guideline to the person.

Section 64 Use of guidelines in proceedings

A guideline is admissible in evidence in a proceeding if—
(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and
(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and
(c) the guideline is about achieving an acceptable level of risk.

Part 3 - Safety and health obligations

Section 34 How obligation can be discharged if regulation or guideline made—

(3) if a guideline states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—
(a) adopting and following a stated way; or
(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

Note: This document is controlled electronically. For the current copy see the Department of Natural Resources and Mines website at http://www.dnrm.qld.gov.au which also has contacts for your local Inspector of Mines.

Contents

Glossary

Activity (Bq/g)	number of atomic disintegrations per second per gram of substance
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ANRDR	Australian National Radiation Dose Register
Alpha radiation	A charged helium nucleus from decay of a radionuclide that imparts potentially harmful energy to humans and may cause injury or illness. Alpha particles have limited travel, but are relatively long-lived and potentially cause most harm when inside the body, e.g. inhaled/ingested
Becquerel (Bq)	The derived International System of Units of radioactivity equal to one disintegration per second
Beta radiation	Beta particles are high-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei
Committed dose	Future personal radiation dose resulting from a radionuclide intake today
DNRM	Department of Natural Resources and Mines
Effective dose	A measure of dose, which takes into account both the type of radiation involved and the radiological sensitivities/susceptibilities of the organs and tissues irradiated. The unit of effective dose is Sievert (Sv).
Guideline	A document outlining mandatory legal requirements under MQSHA
Gamma radiation	Electromagnetic radiation of extremely high frequency and energy per photon. Gamma rays can be produced by the decay of atomic nuclei from high to lower energy states (gamma decay)
Gamma shine	A term used to describe the personal exposure received from an area source emitting gamma radiation e.g. an orebody, stockpile or tailings dam
NORM	Naturally occurring radioactive materials
NORMMP	A NORM Management Plan, which equates to a radiation management plan prepared to the specification in this guideline, not to that in RPS9
RPS9	The Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA, 2005)
Ionising radiation	Any radiation, as a stream of alpha/beta particles or gamma rays, that produces ionisation as it passes through a medium
MQSHA	*Mining and Quarrying Safety and Health Act 1999*
MQSHR	*Mining and Quarrying Safety and Health Regulation 2001*
PPE	Personal protective equipment
Radionuclides	A nuclide that is radioactive
Radon	A radioactive gaseous element. It is a product of ore radioactive decay
RPE	Respiratory protective equipment
Sievert (Sv)	A unit of health risk from any ionising radiation. The risk arising from 1 Sv is the same no matter what kind of radiation causes it.
SHMS	A safety and health management system ensuring an acceptable level of risk at a mine
SSE	Site Senior Executive
TLD	Thermoluminescent Dosimeter – a badge used for the measurement of an individual's exposure to ionising radiation, such as gamma radiation.

Preface

Obligations under Queensland legislation

Legislation requires risk to be eliminated or controlled to an acceptable level.

Obligations exist under the *Mining and Quarrying Safety and Health Act 1999* (MQSHA) to protect the safety and health of persons at mines; and to ensure that the risk of injury or illness to any person resulting from operations is at an acceptable level.

For a risk to a person to be at an acceptable level, operations at a mine must be carried out so that the level of risk from the operation is not only within acceptable limits, but also as low as reasonably achievable.

Obligation holders should refer to the MQSHA and the *Mining and Quarrying Safety and Health Regulation 2001* (MQSHR) for the most recent and relevant legislation. This legislation can be found at: http://www.legislation.qld.gov.au/Acts_SLs/Acts_SL.htm

SSE has obligation to develop and implement a system to manage NORM

Under section 145 of the MQSHR, if a person is likely to be exposed to radiation above acceptable limits, the Site Senior Executive (SSE) has an obligation to develop and implement a system to manage those risks and ensure compliance.

The MQSHA, MQSHR and this guideline will prevail if in conflict with any other legislation or code of practice.

This guideline aligns, where appropriate, the system of radiation protection as recommended by the International Commission on Radiological Protection, International Atomic Energy Agency and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), most notably RPS9 – "The Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)" - with the MQSHA and MQSHR. In the event of any conflict between this guideline made under MQSHA and any other codes made under any other legislation, this guideline will prevail. Unlike RPS9, this mandatory guideline does NOT require approval of any radiation management plan for exploration, mining or processing activities before work commences, in line with risk management principles of the MQSHA. Furthermore, it does not require a separate radiation management plan for waste as RPS9 does.

This guideline does not apply to sealed sources.

This guideline does not apply to sealed radioactive sources, which are regulated under the *Radiation Safety Act 1999* and the *Radiation Safety Regulation 2010* and administered by Queensland Health.

1 Purpose of this document

The purpose of this guideline is to provide information on how to manage risks associated with NORM in metalliferous mines. This includes exploration, operating mines and process plants.

Naturally occurring radioactive materials (NORM), including uranium ore or other mineral deposits containing radionuclides (such as some mineral sands, some rare earth minerals or gold/copper deposits) may pose a risk to workers' health. Similar to any other hazard at a mine, this hazard and associated risks must be managed.

The purpose of this guideline is to provide information to metalliferous mining operations on how to systematically manage NORM risks so that obligation holders comply with the legislative framework. It sets out a risk management approach and the minimum requirements for a NORM management plan for inclusion in the overall safety and health management system (SHMS) for a mine.

The words 'must,' 'requires' or 'mandatory' indicate that legal requirements exist and must be complied with.

The word 'should' indicates a recommended course of action, while 'may' indicates an optional course of action.

This guideline applies to all the operations associated with exploring for, winning and treating ores containing NORM on a mining tenure including, but not limited to:

- exploration activities such as taking soil or water samples, geophysical surveys (excluding airborne surveys), survey pegging, levelling drill pads and digging sumps, drilling, storing core samples (on the mine), bulk sampling, open trenching or costeaning with an excavator and seismic surveying using explosives
- mining activities such as drilling, blasting, loading, transporting, crushing, screening and stockpiling
- treating activities such as concentrating, smelting, leaching, electrowinning, storing and handling the final mineral product
- disposing of waste products in connection with exploration, winning and treating activities
- constructing, erecting, maintaining or demolishing any dam, excavation, building, plant, machinery or equipment associated with exploration, winning and treating ore or disposal of waste products
- rehabilitating during or after exploring, winning and treating activities.

Transport of NORM from a mine.

Transport of NORM from a mine must comply with the "Code of Practice for Safe Transport of Radioactive Materials" (2001), and the Queensland *Radiation Safety Act 1999* and *Radiation Safety Regulation 2010*, both administered by the Radiation Health Unit at Queensland Health.

Storage of large quantities of core not on a mine site.

Core storage areas that are not located on a mine site and contain a significant amount of NORM may need to be registered with Queensland Health

2 What is NORM?

NORM refers to naturally occurring radioactive materials that have a minimum activity of 1 Bq/g.

In this guideline NORM refers to naturally occurring materials containing radioactive elements, such as uranium and thorium or their associated decay products that are within the boundary of a mine. This may include NORM contained within host rock, ores, concentrates, samples and waste materials. The material must have a minimum activity of one Becquerel/gram (Bq/g) to be considered NORM.

One Bq/g is currently the internationally accepted level for defining the scope of regulation for NORM containing uranium and thorium or its decay products. At activity concentrations less than 1 Bq/g, these minerals would be considered inherently safe.

3 What hazard does NORM pose?

NORM is an ionising radiation hazard primarily in the form of alpha particles (in dust and radon) and of gamma shine (as high energy electromagnetic rays).

NORM is an ionising radiation hazard that poses a potential long-term cumulative chronic risk if a person is exposed to it on a regular basis.

There are three types of ionising radiation – alpha, beta and gamma. The two principal types generated by NORM at mines are as alpha (in dust and radon) and as gamma (high energy electromagnetic rays) radiation.

The hazards associated with alpha radiation are inhalation and ingestion. Some known routes of exposure to alpha radiation include:

- inhalation of airborne dust containing NORM;
- inhalation of radon emanating from ore surfaces, for example core, drill cuttings broken ore stockpiles or underground drives or from groundwater entering or collecting in underground drives;
- inhalation of fume containing radioactive components such as polonium in copper smelting operations;
- ingestion of radionuclides, for example via dust on skin transferred to the mouth while eating; and,
- absorption through skin of liquids or inhalation of airborne mists of pregnant solvent or solutions containing NORM.

The hazard for gamma radiation is from whole body exposure to sources, commonly referred to as ‘gamma shine’. These sources of gamma radiation include:

- tailings dams
- ore bodies
- drill cores and other samples
- ore stockpiles
- radium scale deposits.

4 Risk management

4.1 Hazard identification and risk analysis

Risk analysis and evaluation are the processes that determine the level of risk of injury or illness associated with a hazard and decide which risks need controls.

All exploration and mining activities must determine if encountering radioactivity during the operation is possible. A test on the minerals may be required to ensure the radiation levels are not problematic.

A site assessment is required for activity concentrations greater than 1 Bq/g to determine the risk. Where it is likely the potential dose may exceed one millisievert per year (mSv/y), a comprehensive risk assessment must be carried out and controls implemented according to the level of risk.

The risk needs to be controlled throughout the life cycle of the operation. These assessments may be required a number of times. For example:

- prior to exploration or after discovery of radionuclides during exploration activities
- during planning of mining and processing operations
- after commencement of operations or subsequent discovery of radionuclides after commencement
- monitoring indicates that the risk may not be as low as reasonably achievable
- when there are significant changes or every five years, whichever is the lesser
- prior to rehabilitation and abandonment of the mine.

The Site Senior Executive (SSE) must ensure that any risk assessment completed under the mine's established risk management practices and procedures meets the legislative requirements under Part 2 of MQSHR.

The risk assessment should include and consider where appropriate:

- radionuclides and quantities
- nature of proposed operations and activities
- routes of exposure, including gamma shine, inhalation of dust (as long lived alphas), radon and ingestion
- qualifications/competencies of people for assessing and quantifying the risks associated with NORM
- what controls might be used
- levels of exposure in national standards
- workers exposure data
- changes to plant, processes or substances at the mine
- changes to legislation
- new knowledge about NORM hazards or controls.

The risk assessment for NORM encountered during work activities must include workers involved in the activities being risk assessed and suitably qualified and competent persons.

The risk assessment must consider all relevant and available information relating to the hazard and controls.

A copy of the risk assessment must be kept at the mine for the duration for which the hazard exists. The risk assessment must include:

- the names of the people involved in the risk assessment and their respective positions in the mine's management structure
- a description of the hazard
- the method for assessing the likelihood and consequence of the risk
- the controls proposed to reduce the risk.

The risk assessment should also include the names of the persons responsible for implementing the controls

4.2 Exposure limits for NORM

There are established exposure levels to NORM.

The exposure limits (effective dose) as established by Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) for ionising radiation are:

Limit on effective dose[i],*		
To limit individual risk	**For occupational exposure** 20 mSv per year averaged over 5 years[ii],*	**For members of the public** 1 mSv in a year*

i. Limits shall apply to the sum of the relevant doses from external exposure in the specified period and the 50-year committed dose (to age 70 years for children) from intakes in the same period.

ii. With the further provision that the effective dose shall not exceed 50 mSv in any single year. In addition, when a pregnancy is declared by a female employee, the embryo or fetus should be afforded the same level of protection as required for members of the public.

* For details, see ARPANSA's "Fundamentals for protection against ionising radiation" (2014) and sister publications.

NORM radionuclide elements and substances may also pose chemical toxicity risks.

In addition to any radiological limits of exposure, the toxic effects of any substance must also be considered. For example, uranium and uranium compounds are classified as very toxic by Safework Australia. The quoted time weighted average for exposure is 0.2 mg/m^3 with a short-term exposure limit of 0.6 mg/m^3.

For further details see the Hazardous Substances Information System at http://www.hsis.safeworkaustralia.gov.au/HazardousSubstance/Details?hazardousSubstanceID=6302

4.2.1 Complying with exposure limits

Complying with exposure limits protects most people from the health effects of a particular substance.

ARPANSA (2005) states:

"Compliance with the occupational limit on effective dose will ensure that deterministic effects do not occur in most body tissues and organs."

A deterministic effect is defined as an effect, such as partial loss of function of an organ or tissue, caused by radiation and manifest only above some threshold of dose, the severity of the effect depending upon the dose received.

Safe Work Australia (2012) also states the following about complying with exposure limits of atmospheric contaminants:

"Exposure limits represent the airborne concentration of a particular substance or mixture that must not be exceeded. Exposure limits are based on the airborne concentrations of individual substances which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all workers. Exposure limits do not represent a fine dividing line between a healthy and unhealthy work environment. Natural biological variation and the range of individual susceptibilities mean that a small number of people might experience adverse health effects even below the exposure standard."

In practice, this means that if monitoring indicates exposure is below the acceptable limit, efforts should still continue to reduce the worker's exposure to as low as reasonably achievable.

4.3 Approach for assessing and managing occupational exposures

The risk management process may require specific risk assessment methods to be used when managing occupational exposures of ionising radiation.

Assessing and managing risks associated with occupational exposures can be complex. The risk management process may require the use of specific risk assessment techniques.

For example, assessing risk from occupational exposures to NORM could include measuring workers exposure by sampling the work environment, e.g. collecting personal dust or measuring total gamma shine using a Thermoluminescent Dosimeter (TLD) tag.

The approach to assessing risk must be established by an appropriately competent person, such as an occupational hygienist or experienced medical practitioner.

The approach outlined in Figure 1 shows the relationship between each of the legislated risk management processes and some of the technical and administrative activities.

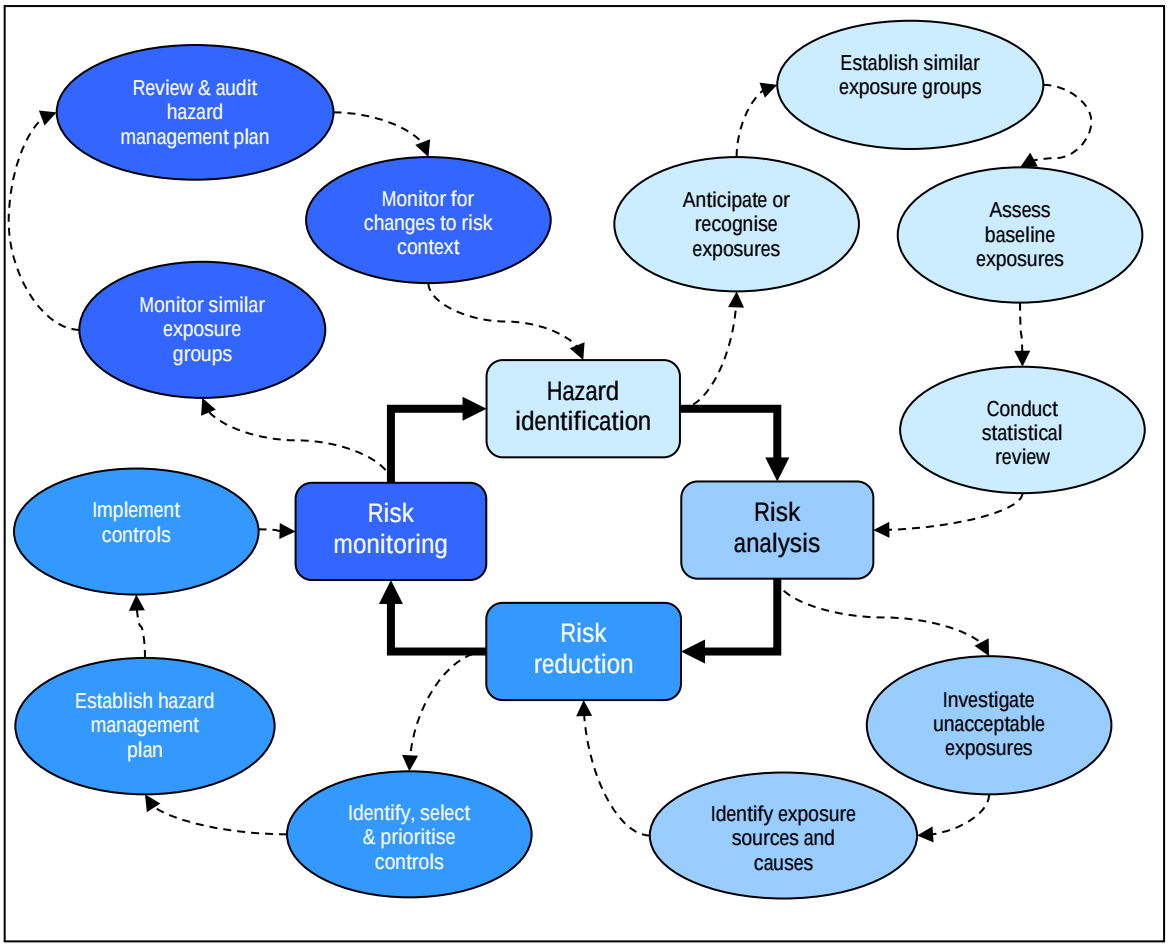

Figure 1 - Approach to assessing and managing occupational exposures, (Grantham 2001; Standards Australia 2001; Ignacio & Bullock 2006)

4.4 Risk reduction

Examples of the hierarchy of control for NORM.

Persons with an obligation under the MQSHA to manage risk at a mine must apply hazard controls using the hierarchy of controls shown below:

a) elimination of the hazard
b) substitution with a lesser hazard
c) engineering controls (including isolation of persons)
d) administrative (often referred to in radiation safety as 'institutional') controls (including training)
e) personal protective equipment.

The hierarchy of controls must be applied ensuring workers' exposure to NORM does not exceed the limit and is as low as reasonably achievable.

The following sections describe some of the possible controls that should be considered for risk reduction.

4.4.1 Mine and process plant design

Mine planning and design can have a significant effect on worker exposure.

The risk reduction to NORM starts at the mine planning phase. Design of the mine and associated process plant and infrastructure can have a significant impact on future workers' exposure.

For example:

- designing access drives though rock with low activities
- minimising broken ore stockpiles and process inventory
- locate control rooms a safe distance away from the process plant
- consider prevailing winds and weather conditions to reduce dust.

4.4.2 Dust suppression and extraction

Control of dust will reduce overall exposures.

Effective dust suppression and extraction will reduce exposure to alpha emitters through inhalation. It is important to identify all areas of dust generation, which can include exploration drilling, mining excavation activities, roads, stockpiles, conveyor transfer points and process operations.

Specific control measures can include:

- watering roads, stockpiles, faces and points that generate dust
- installation of pens or sheeting acting as wind breaks for stockpiles
- use of dust suppression additives
- controlling spillage and cleaning up as soon as practicable
- enclosed local extraction ventilation containment systems fitted to control dust generated during drilling, crushing and processing
- avoiding re-suspension of NORM dust as a result of equipment vibration, high air velocities, and movement of equipment during maintenance operations
- installing dust suppression on crushing, screening and conveyor systems at appropriate locations
- appropriate disposal of captured dust.

4.4.3 Ventilation

Ventilation can be used to remove or dilute the amount of NORM.

Ventilation is the primary control for managing alpha-emitting dust and radon in an underground mine.

Ventilation can remove or dilute the amount of alpha-emitting NORM (as dust and radon) present in the atmosphere to an acceptable level before it enters the breathing zone of a worker. It does not reduce or otherwise control gamma shine.

The ventilation of air in a place where a person may be present must be of a sufficient volume, velocity and quality to achieve a healthy atmosphere.

To achieve a healthy atmosphere an estimate of the total quantity of NORM produced and the location of workers in the ventilation circuit is required.

This estimate must be considered in addition to other ventilation requirements such as controlling heat or diesel particulate matter.

Consider the ventilation of other enclosed spaces at the mine, such as surface ore bins, where dust and radon may accumulate and workers can be exposed. Where general dilution ventilation is not effective, local exhaust ventilation will be required.

4.4.4 Enclosed operator cabins

Enclosed cabins may provide protection to operators inside the cabin from NORM.

Enclosed cabins on plant and equipment with appropriately maintained seals and air-conditioning should be designed, installed and maintained to provide protection to operators inside the cabin from NORM.

Consideration should be given to workers required to maintain this equipment. For example, filters may concentrate dust and radon thereby increasing the exposure risk to people replacing or working near them.

4.4.5 Maintenance

An effective maintenance strategy can reduce the type and amount of NORM exposure.

Poorly maintained plant will compromise any of the measures implemented to manage and control exposure to NORM.

If a breakdown of the plant can cause an unacceptable level of risk from NORM, the plant's servicing and maintenance must be based on a preventive strategy. The plant or equipment must be taken out of operation, if it cannot be serviced or maintained to ensure it is able to function or operate within its performance limits.

Exposure of maintenance personnel to NORM should be considered when risk assessing maintenance activities.

4.4.6 Separation of workers from NORM

Separation of workers' from the hazard of NORM will reduce their exposure.

Separation distance will directly affect the exposure to gamma radiation. Effective strategies for reducing or controlling workers' exposure to NORM can include:

- using remote operated or autonomous equipment
- locating non-critical plant and infrastructure such as administration in areas of low background exposure
- locating control rooms outside of the process plant
- establishing exclusion zones or controlled access around 'hot' areas.

4.4.7 Shielding and sealing surfaces

Sealing surfaces and shielding sources may reduce the exposures.

Shielding can also be an effective control for radiation.

Practical examples include:

- storing known 'hot' core in the middle of other core sample trays and pallets of core
- concrete walled bunkers may provide some protection for stockpiles
- coating underground development with an appropriate thickness of shotcrete may reduce gamma shine
- subject to any environmental authority conditions, burying exploration drill cuttings, samples and mud pits under at least one metre of compacted soil. Note drill samples should be mixed with soil prior to burial to reduce any artificial concentration of the material.

4.4.8 Procedures and work practices

Procedures, Safe Work Instructions and work practices can reduce the type and amount of NORM exposure.

A risk assessment may identify that certain written procedures and standard work instructions are required to manage the risk of NORM.

Work procedures and practices are only effective if uniformly and consistently applied and followed.

Examples of written procedures, standard work instructions and work practices that can reduce NORM exposure include:

- pre-start checks to ensure that the dust control, suppression, extraction and ventilation systems are operating and effective
- hygiene standards, rules and practices
- clean-in/clean-out facilities and procedures
- maintenance of suitable clean crib rooms and facilities
- housekeeping standards
- decontamination of equipment prior to leaving site or being maintained
- capturing exposure history completely and accurately
- exclusion or limiting work time of persons from high dose areas
- sample handling, transfer and storage procedures
- product storage and transport practices and procedures
- waste management procedures
- removing muck from drives and development headings as soon as possible.
- procedures for calibrating monitoring equipment.

4.4.9 Education, training and competency

Education, training and competency can reduce risk of exposure to NORM

The SSE has an obligation to train workers so that they are competent to perform their duties where there are risks from NORM. This will include **both** appropriate induction training with periodic assessment of knowledge of risk management for NORM **and** any other relevant and appropriate training with periodic assessment required to effectively implement the NORMPP. This will include appropriate workers obtaining any relevant competencies recognised by the Mining Safety and Health Advisory Committee.

In conjunction with MQSHR section 91 “Induction training and assessment” relevant induction training for workers who may be exposed to NORM should include but not be limited to the following topics:

- basic principles and terminology of radiation
- hazards of NORM
- risks from radiation exposure
- routes of entry and typical exposure controls
- role of monitoring and dose limits and measurement
- overview of NORM management Plan.

A competent person must be appointed to supervise a radiation monitoring program. The person must be:

- appropriately trained in occupational hygiene principles
- competent in the use of the applicable equipment and procedures
- be able to perform in-situ monitoring of exposure to radiation
- interpret monitoring results
- recognise exposure at an unacceptable level and
- where required, appropriately act to either remediate control or otherwise ensure safety.

A certified Radiation Safety Officer - as appointed by Queensland Health - may perform the duties of a person to supervise a radiation monitoring program subject to meeting the competency requirements including obtaining any relevant competencies recognised by the Mining Safety and Health Advisory Committee.

Training and competency requirements for supervisors and workers must be developed and documented. This should include requirements to have a more detailed understanding of NORM, the risk controls relevant to their work and the ability to recognise substandard conditions or practices relevant to NORM.

4.4.10 Personal protective equipment (PPE)

Respiratory Protection when properly selected, fitted and used can provide some protection to people from NORM.

PPE is the lowest order control in the hierarchy of control and relies heavily on worker compliance and enforcement by supervision to be effective. Failure to wear suitable, correctly fitted PPE, when required can result in a worker being directly exposed to the hazards associated with NORM.

It is recommended that respiratory protective equipment (RPE) to prevent exposure to NORM is only used as a temporary or interim control. Every effort should be made to reduce NORM to levels that do not require the use of respiratory protection.

It is important to note that RPE will only reduce the risk from alpha emitters, but will not reduce the risk from gamma shine.

Additional PPE may include coveralls, goggles and gloves. Further guidance about the selection, use and maintenance of respiratory protection is provided in AS/NZS 1715: 2009 - Selection, use and maintenance of respiratory protective equipment.

4.5 Risk monitoring

Risk monitoring is the process of ensuring risk controls are effective; gathering further information to improve risk analysis; and indentifying changes in the risk management context and emerging risks.

Risk monitoring is the process of monitoring and reviewing all parts of the risk management process and can be a periodic or unplanned activity.

The SSE must ensure the mine and local environment is monitored throughout the lifecycle of operations at the mine and when changes occur that can affect the level of risk at the mine.

The aims of risk monitoring are to:

- review implementation of controls
- ensure controls are working as designed/intended
- incorporate new research, trends or industry data into risk management processes
- obtain additional information to improve the risk analysis process.

In the context of NORM, risk monitoring may include, but not be limited to:

- the use of TLD badges
- personal exposure dust monitoring
- environmental dust monitoring
- radon measurement
- gamma shine measurements
- surface contamination monitoring
- ensuring there is compliance with work procedures and work practices.

4.5.1 Monitoring workers' exposure

Monitoring workers' exposure must comply with relevant legislation.

The SSE must ensure monitoring of workers' exposure to NORM is completed under the mine's established SHMS and meet the legislative requirements under Parts 2 and 14 of the MQSHR.

Monitoring must meet certain requirements for it to be valid.

Monitoring is required to be performed when a hazard, such as NORM, has the potential to exceed exposure limits, or the level of risk from the hazard may vary.

If a relevant Australian Standard or National Standard states a way to monitor or analyse, the SSE must ensure it is done in the stated way.

The approach to implementing a monitoring program must be established by an appropriately qualified person, such as an occupational hygienist.

Once a baseline of personal exposure is established – and only when the controls used are proven to reduce exposure to an acceptable level – can the program be reviewed, and the frequency and type of monitoring varied.

Monitoring equipment must be calibrated.

Personal dosimeters should be stored appropriately between uses and not be exposed to any unrepresentative radioactive source.

An air monitoring program can be used to assess if a workers' exposure to NORM is at an acceptable level.

Exposure assessment requires a sound understanding of the:

- work environment
- workforce
- work processes and equipment
- nature of the hazard
- strategies for assessing exposure
- methods of sampling and analysis
- relevant statistical techniques
- interpretation of results.

The monitoring program must be documented and state the exposure assessment goals and strategy.

Results of any monitoring must be communicated to either individuals or work groups as appropriate in a timely manner.

Changes to plant, processes or substances and the results of previous NORM exposure assessments can be used to determine how often worker exposure should be reassessed.

Reassessment of worker exposure is required throughout the lifecycle of operations at a mine when changes occur that can significantly alter the level of risk at a mine. Change management practices and procedures should require reassessment of worker exposure when there has been change to plant, processes or substances at the mine.

Management of change is not the only reason to conduct risk monitoring. Reassessment of worker exposure can also be used to verify the effectiveness of newly implemented risk controls and also to detect subtle deterioration of these risk reduction measures over time.

The frequency and purpose of reassessment required for workers or groups should be determined by an appropriately qualified person. However, due to the expense and time required, exposure reassessment should not be conducted for its own sake.

4.6 Records

Records need to be kept and results communicated.

The NORM management plan must include provisions for reporting the results of the monitoring program and any related information.

Monitoring records, dose assessments including calculation methods and related information, must be retained and able to be accessed when required. All evidence of competencies shall be available & accessible at the mine site at all times.

Any records of monitoring and analysis must be kept for 30 years. Reports of monitoring results must be supplied to management and workers, both individually and to the work group.

The occupational exposure results of individual workers must be provided to the Mines Inspectorate in an approved form. This information will be provided to ARPANSA for inclusion in the Australian National Radiation Dose Register (ANRDR). ANRDR was established to enable workers' dose records to be tracked and recorded throughout their career and to make available to workers, summaries of their periodic and cumulative exposures.

5 NORM management plan

A NORMMP must be developed where NORM is a potential hazard

Where NORM is a hazard at a mine, a NORM management plan (NORMMP) must be developed and must:

- align with the goals and objectives of the mine's SHMS
- be established using the mine's risk management practices and procedures
- address all relevant activities and processes at the mine
- be integrated and compatible with the mine's SHMS
- be documented and auditable.

A NORMMP must be developed at the exploration stage if uranium is a target mineral.

A NORMMP may also need to be developed at the exploration stage when:

- target minerals are in an area of known NORM occurrence
- target minerals have a known association with NORM e.g. copper, gold, rare earths, mineral sands

A current copy of the NORMMP must be kept on site and available to workers.

The contents of the NORMMP should include the sections shown below:

Purpose of the NORMMP

Include:

- description of the type of NORM minerals mined and level of potential radiation
- how the NORMMP fits within the SHMS.

Scope of mining activities
Include:

- a brief overview summarising the key processes done on site, including waste management.
- a process flow chart and list of the principal equipment involved.

Organisational arrangements for managing NORM
Include:

- company organisation chart and management structure showing responsibilities and competencies for NORM radiation management.

Workforce arrangements
Include:

- number of workers and roles
- roster arrangements
- hours of work and the likely annual working hours (to estimate dose).

Routes and risk of exposure to radiation
Include:

- sources and magnitude of NORM
- possible modes of exposure e.g. inhalation, absorption, invasion and ingestion
- identification of transfer or storage areas for NORM e.g. stockpiles and hoppers.

Engineering control of radiation
Include:

- a list of the engineering controls, for all routes and identified areas of exposure, implemented to reduce exposure to an acceptable level.

Administrative control of radiation
Include:

- administrative risk reduction controls to limit exposure
- a list of written procedures and safe work instructions (SWIs) relating to radiation management.

Education, training and competency
Include:

- a copy of the site's training matrix showing what competencies workers require and hold in relation to NORM.

Radiation monitoring program
Include:

- details of the radiation monitoring program
- written procedures and SWIs for the monitoring program including operating and maintenance of the monitoring equipment
- list of monitoring equipment.

Dose assessment
Include:

- estimate of worker category exposure per project and annum
- suitable and sufficient scientific justification for any models assumptions or data used in the estimation process
- an explanation of how the results of the monitoring program are used in the assessment/measurement of workers' doses.

Monitoring records and reporting
Include:

- worker category exposure results and any fixed monitoring results
- monitoring reports
- procedure for responding and investigating unacceptable variances from a worker's expected exposure level and/or dose estimate.

Management of product
Include:

- details of the handling, storage and transportation methods of NORM products.

Management of waste
Include:

- details of the handling, storage and disposal methods of NORM waste including residues on site.

Emergency response plan interaction
Include:

- explanation of the impact NORM may have on the mine's emergency response procedures and capabilities.

Review and audit
Include:

- procedures for periodic review, audit and continuous improvement of the NORMMP.

6 Review and audit

The effectiveness of the NORM management plan must be reviewed and audited by the Operator of the mine.

The operator of the mine is required to review and audit the effectiveness of the Mine's SHMS, including subsystems such as the NORM management plan, to ensure risk to persons from operations is at an acceptable level.

Further guidance about how to review the effectiveness of the NORM management system is provided in Guidance Note QGN09 – Reviewing the effectiveness of safety and health management systems on the DNRM website.

7 References

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