NORM Management Guidelines

Curtin Health and Safety Department

6 Sep 2023

Introduction

Purpose

This guide has been written to help Curtin University workers (i.e. staff, students, contractors, and visitors) understand their duties under legislation and to promote University-wide safe management practice for use and storage of Naturally Occurring Radioactive Material (NORM). It aims to provide a consistent approach while remaining flexible enough to accommodate differing work practices and levels of risk. The guide also provides advice on radiation protection measures to minimise risk for all workers dealing with NORM.

The mining and mineral processing industry has legislation, codes of practice and safety guides for use of NORM. Most of these rules and guidance materials relate to the extraction and processing of large quantities of ore. There is comparatively little guidance for other industries such as the tertiary education sector where NORM could be used in a research or teaching environment. When projects are undertaken in conjunction with the mining industry, the relevant legislation, codes and guidelines should be adhered to. The present guide is not intended to replace those codes and guidelines but to supplement them by providing additional guidance on University-specific matters.

Scope

This guide applies to all Curtin University premises and to all University workers dealing with NORM.

Radiation management structure

The University has a four-tier structure for radiation management:

- Radiation Safety Committee
- Radiation Safety Officer
- Radiation Safety Supervisors
- Radiation users.

All University workers must adhere to the relevant requirements and report any safety, health or security concerns. A full description of responsibilities related to radiation safety can be found in the Radiation Safety Manual.

Acquisition and disposal of NORM

The Radiation Safety Officer (rso@curtin.edu.au) must be informed before acquiring or disposing of NORM. This includes acquisition through fieldwork.

Dealing with suppliers

Obtain details of the NORM from the supplier prior to any arrangements for shipping to University premises. Details of the material should include isotopic composition, specific activity, and total amount of material. If the supplier cannot provide information on the specific activity then an initial assessment of the hazard must be made as described in Classifying NORM. The information should be supplied in writing to the University, with a copy supplied to the RSO and the relevant RSS. The School should then determine appropriate controls in consultation with their RSS.

It is strongly recommended that arrangements be made to return NORM to the supplier at the completion of the project for which it is being acquired.

Classifying NORM

These guidelines use the following scheme to classify NORM:

Class	Descriptor	Specific activity (SA, Bq/g)	Surface dose rate (DR, μSv/h)	Annual dose (mSv)	Controls
1	Exempt	SA < 1	0 ≤ DR < 0.25	0.4	None required though class 2 controls are recommended.
2	Low level	1 ≤ SA < 10	0.25 ≤ DR < 2.5	4	Practise safe operating procedures to eliminate inhalation or ingestion when handling unsealed material (e.g. wear a dust mask and disposable gloves); ensure work areas have adequate ventilation (at least 1-3 air changes/hr); store in a sealed container; store small quantities (< 1 kg total) at least one metre from regularly occupied areas; store bulk quantities (≥ 1 kg total) at least ten metres from regularly occupied areas
3	Medium level	10 ≤ SA < 100	2.5 ≤ DR < 25	40	Class 2 controls plus personal radiation monitoring

Class	Descriptor	Specific activity (SA, Bq/g)	Surface dose rate (DR, µSv/h)	Annual dose (mSv)	Controls
4	High level	SA ≥ 100	DR ≥ 25	> 40	Class 3 controls plus further controls as directed by the Radiation Safety Committee; not to be brought onto University premises without written approval from the Radiation Safety Committee; a prerequisite for approval is submission of a NORM Management Plan as outlined in ARPANSA (2008) sec. 4.4.6.

Notes:

- Prefer specific activity over surface dose rate when determining class. Specific activity must be used if the surface dose rate is 2.5 µSv/h or greater. (In field conditions, an initial determination can be made using the surface dose rate.)
- Specific activity must be determined by an approved analytical method.
- Annual dose is a worst case estimate based on a specific activity to dose rate conversion factor of 0.4 mSv/y per Bq/g. The actual dose is not expected to exceed 10% of the worst case estimate. (See ARPANSA (2008) table 8.)
- *Surface dose rate* means the maximum net dose rate measured on any surface of the container. (Beware of contaminating the survey meter. Placing it in a plastic bag is a good idea.) There is no need to open containers to do surface dose rate measurements. (Gamma emissions from NORM are highly penetrating.)
- The surface dose rate cannot be used to estimate specific activity in the case of pure alpha emitters because only a small proportion of alpha particles are detected by typical survey meters. This is unlikely to be a problem in the case of unprocessed NORM as uranium and thorium decay chains contain a number of beta and gamma emitters.

Determining specific activity

Specific activity of a material can be determined by reference to the supplier's information about the material or measurement using an analytical technique such as ICP-MS.

An initial estimate can be obtained using the values in the Summary of NORM specific activities below. If the material contains a number of components then use a weighted average that assumes the highest listed specific activity for each component. If the material fits into the highest activity category of the *Summary* (i.e. > 20 Bq/g) then please contact the RSO for guidance.

In situations where the specific activity cannot be determined (e.g. when collecting from a field site), use the surface dose rate to obtain an initial classification so that appropriate controls can be put in place. **A radiation monitor calibrated in microsieverts per hour is required to be on hand if you are planning to collect potentially radioactive material from field sites.**

Additional interim controls

If the specific activity of a material is not known upon first contact (e.g. collection from a field site) then an interim classification must be made on site using the surface dose rate method. The following table specifies controls that are required **in addition to** those listed for the class in the Classifying NORM section above.

Additional controls required for NORM

Class	Additional interim controls
1	None
2	Adopt procedures that minimise handling time. Materials must be stored and transported in sealed containers. Contact the RSO for guidance prior to transport. Place containers as far as possible from people during transport.
3	Class 2 controls plus labelling, placarding, and consignment declarations required by the *Transport Code* (ARPANSA 2019).
4	**Do not collect.** Leave the material at the field site. Seek direction from the Radiation Safety Committee concerning possible future collection.

A radiation survey meter suitable for detecting beta and gamma radiation should be used to measure dose rates. The meter should be calibrated in dose rate units (e.g. microsieverts per hour). A background dose rate should be measured at least 10 metres away from collected NORM samples and recorded. The background dose rate should be subtracted from the reading when measuring the surface dose rate of a sample. Please note that background dose rates can vary considerable from one site to another. (The background dose rate on the coastal plain in Perth is about 0.15 microsieverts per hour. Use a background dose rate of 0.15 microsieverts per hour if you suspect that samples are being collected from a high background area, as indicated by a dose rate of more than 0.25 microsieverts per hour when more than 10 metres from collected samples.)

If a number of samples are placed in a container then it is acceptable to use the maximum surface dose rate on the container to establish the interim classification.

Risk assessment

A risk assessment must be conducted for all NORM with specific activities above exempt levels. This must be in addition to any assessment addressing other types such as chemical and physical risks. The risk assessment must be made with reference to the hierarchy of safety controls (i.e. elimination, substitution, isolation, engineering, administrative, PPE). Consideration must be given to dust suppression/extraction, ventilation, separation distance, shielding, work practices, training, PPE, risk monitoring, work surfaces, spills management and record keeping.

The risk assessment should also reflect the expected storage and working practices as described in the remainder of this section and the NORM management section. NORM can present both an internal and external radiation hazard, so the risk assessment should account for both.

Risk assessments should be done using the CHARM system (please see Risk Assessments). Please nominate your line supervisor as the approver and invite the School RSS as a peer reviewer.

The risk assessment must be carried out by the workers who will be dealing with the NORM. It is not necessary to work under a radiation licence in order to complete the risk assessment, although this risk assessment must be conducted in liaison with the RSS for the School to ensure all relevant personnel will be made aware of the work. The risk assessment should show that the ALARA principle is being applied with respect to minimising radiation exposure to workers, and can do so by referring to Safe Work Procedures that demonstrate how this exposure is minimised. Additional information and templates can be found on the Health and Safety website.

More comprehensive information about exposure pathways and NORM risks can be found in ARPANSA's *Management of Naturally Occurring Radioactive Material* (ARPANSA 2008).

Exposure pathways

Consideration should be given to potential internal exposure, for which the most common modes of entry to the body are inhalation and ingestion. When considering inhalation, it is important to take into account the potential build-up of Radon, which is a daughter radionuclide of radium and present in most rocks, soils and minerals which are naturally occurring radionuclides. These internal exposures can result from the decay of radionuclides within the body where radionuclides usually enter the body via inhalation, ingestion, and wounds, and by absorption through the skin.

Alpha radiation has the greatest effect for internal exposures, because its relatively high energy and low penetrating power means that all the energy of the alpha particle is deposited in a short distance when it passes through tissue. External exposures occur when the radiation source is outside the body. Gamma radiation has the greatest external exposure effect, while Beta radiation presents both an internal and external concern. Doses from external exposure depend on factors such as the duration of the exposure, proximity to the radiation source, the radionuclide concentration, and the presence of shielding material.

Doses resulting from internal exposures depend on radionuclide concentrations and chemical form of the material being handled, dust generated from the material, the duration of the exposure, and the rate of intake into the body.

Risks when handling NORM

Certain procedures have the potential to generate dust containing NORM. NORM often contains alpha emitters, which pose a radiological risk if inhaled. Handling of materials containing NORM can result in the deposition of contaminated material on the skin or on clothing. For solids the main issues are deposition of dust on clothing and exposed skin. Where liquids are being handled, splashing onto clothing and exposed skin can be an issue. Material deposited on clothing can be transferred to the hands by rubbing. The radiological risk associated with this pathway can be significantly reduced by following good hygiene procedures, such as washing the face and hands before eating, and removing contaminated clothing before leaving the workplace.

Project approval

Projects involving NORM of classes 2, 3, or 4 according to the above scheme must be approved by the RSO prior to the commencement of radiation activities. (Please contact the RSO to obtain an application form.) Workers involved in the project must create and submit a project application, together with their risk assessment and safe work procedures. In some cases it is necessary to seek approval from Government Regulators or make alterations to a facility. As such, it would be prudent to make the project application well in advance of the projected commencement of work.

NORM management

Storage

The findings of the risk assessment should be considered when determining a suitable storage location. In poorly ventilated areas the build-up of radon levels can be a cause for concern. As such, the area must be ventilated sufficiently to prevent the build-up of Radon. The minimum outdoor fresh air flow per unit of total floor area should be at least 3 litres per second per square metre (Laboratory Design and Construction Committee 2010).

Except in unusual circumstances, storage of NORM wastes and residues should not be considered as a long term management option due to the very long half-lives involved. Storage may require the construction of permanent or semi-permanent facilities with means of restricting access. Waste must be dealt with in accordance with the Disposal section below.

Training

All NORM must be stored in a secure location that can be accessed by authorised workers only. To become authorised an individual must have radiation safety training and must have the permission of the local RSS to store the material in the proposed location. Training may consist of familiarity with relevant risk assessments and safe work procedures or may be a more formal training program, depending on the extent of the hazards. The RSS, in consultation with the RSO, will determine the level of training required for any particular location within their School, and will maintain a list of authorised workers for that location.

Handling

Handling NORM sometimes has the potential to generate high concentrations of airborne dust, which can pose an inhalation risk. Controls should be put in place to ensure any potential inhalation or ingestion is minimised. This should be done by taking into account the nature and frequency of dust-generating activities, and should be documented in the risk assessment. Machinery used for dry separation of minerals must incorporate dust extraction systems to keep dust levels within acceptable limits. Dust extraction hood should be considered when working with large volumes of material as these hoods perform better than fume cupboards when dealing with large amounts of dust. Where materials are transported in dry form, dust mitigation must be employed to keep dust levels in work areas within acceptable limits.

Monitoring of elevated specific activity NORM

The area surrounding the secure location must be surveyed whenever new material is introduced to the location. An estimate must be made of the amount of time workers occupy the surrounding area to obtain a projected dose for comparison with public dose limits. Projected doses must be less than 20 μSv/hr, 250 μSv/week or 1000 μSv/year (Western Australia 1983 Schedule I(3)).

If the secure location is large enough to be occupied by workers (e.g. a storeroom) then the interior of the location must be surveyed whenever new material is introduced. Calculate projected doses for occupying workers and compare with dose limits. Doses to designated radiation workers (i.e. those being monitored for radiation exposure) must not exceed 1.25 mSv/month or 6 mSv/year (Western Australia (1983) Regulation 15 & Schedule I(1)). If the location may be occupied by individuals who are not designated radiation workers then the above public limits apply.

Occupancy factor for elevated specific activity NORM

An occupancy factor can be applied to assist in estimating the amount of time workers are exposed to radiation. Occupancy factors are routinely used in radiation protection calculations. The estimated dose is obtained by multiplying the dose rate by the occupancy factor and the period over which the location will be occupied. Occupancy factors are used for areas containing the NORM material and adjacent areas as well. The following occupancy factors are taken from (NCRP 2005 table B.1).

Occupancy factors

Occupancy factor	Location
1	Areas occupied full-time by an individual, e.g. administrative or clerical offices, receptionist areas
0.2	Corridors, employee lounges, staff rest rooms, classrooms
0.05	Toilets, storage areas, outdoor areas with seating, unattended waiting areas, broom closets
0.025	Outdoor areas with only transient pedestrian or vehicular traffic, unattended parking lots, vehicular drop off areas, stairways, unattended elevators

Inventory check

The RSS will conduct an annual inventory check of the materials in accordance with the requirements of the National Regulator, the Australian Safeguards and Non-proliferation Office (ASNO), and submit this to the University RSO at the relevant time. The RSO will collate all information from across the University and correspond with the Regulator to ensure the University meets its compliance requirements.

For elevated specific activity material it will also be necessary to notify the RSO whenever there is an increase in the total activity of material present in a location.

Disposal

Sustainable processes minimise waste production and utilise as much residue as possible. Appropriate management and disposal of waste NORM depends on factors such as radionuclide concentrations, physical form (solid, liquid or gas) and chemical composition. Environmental impact can be limited by reducing the mobility of the waste (e.g. by solidification) and use of engineered barriers.

Return to supplier

The first preference for disposal is to arrange for the material to be sent back to the supplier when it is no longer required. Final disposal should be organised with the supplier when the material is first acquired. If it is not possible to arrange for the material to be returned then a disposal plan must be devised and included in the radiation project application associated with use of the NORM.

Exempt NORM

NORM is not considered radioactive if the combined activity of its constituents is less than the exemption limits set out in the Radiation Safety (General) Regulations 1983. The RSS in consultation with the RSO will determine a suitable disposal route for this type of NORM after performing chemical and physical risk assessments for the material.

Non-exempt NORM

NORM that is not exempt under the Regulations must be disposed of in accordance with the requirements of the Radiological Council. In the case of TENORM, ASNO requirements (see below) may need to be satisfied as well. There may be significant barriers to disposal of some types of material. In all cases, permission for disposal must be obtained from the relevant regulatory authorities. Disposal costs (e.g. $30 per gram) must be borne by the relevant School.

ASNO requirements

Technically enhanced NORM that contains plutonium, thorium, or uranium may be subject to Australian Safeguards and Non-proliferation Office (ASNO) disposal requirements (e.g. dispersion at 0.05% by weight). Such material can be disposed of by formal transfer to another ASNO permit holder (e.g. a disposal company with an ASNO permit). Otherwise a disposal permit must be sought from ASNO. This will require the RSS in consultation with the RSO to describe how the material will be made practically irrecoverable (e.g. by dispersion at 0.05% by weight).

Summary of NORM specific activities

This table reproduces information extracted from (Cooper 2005 table 14).

Specific activity (Bq/g)	Material
0-1	Oil (sands and sludge); oil (hard scales and films); synthetic rutile; ceramics; sand blasting materials; oversize from secondary mineral sands separation; alumina residues (red mud); coal ash (bottom ash & fly ash); titanium dioxide pigment, neutralised titanium slurries & solids from effluent treatment; Furnace and metal smelter slags; phosphogypsum; phosphate fertilisers; water treatment sludge; tantalum tails; copper tailings; ores (eg coal, bauxite, iron ore) & virgin excavated natural material (VENM); heavy minerals (concentrate, ilmenite, rutile, zircon) & synthetic rutile; building materials & building/demolition waste
1-5	Oil (sands and sludge); oil (hard scales and films); tantalum products; oversize from secondary mineral sands separation; dust from secondary mineral sands separation; phosphoric acid; heavy minerals (concentrate, ilmenite, rutile, zircon); superphosphate & phosphate rock; alumina residues (red mud); solids from effluent treatment (titanium dioxide pigment production)
5-20	Oil (sands and sludge); oil (hard scales and films); dust from secondary mineral sands separation; tantalum concentrate; tails from secondary mineral sands separation

Specific activity (Bq/g)	Material
> 20	Zircon dusts; copper smelter dusts; oil hard scales and films; iron sinter dusts; monazite concentrates; monazite tailings; tantalum concentrate; tails from secondary mineral sands separation

Notes:

1. NORM materials are typically comprised of raw process materials, products, byproducts and recycled materials, waste and other residues.
2. Concentration ranges relate to long-lived members of the natural uranium and thorium series (e.g. U-238, Ra-226, Pb-210, Th-232, Ra-228).
3. Typical Australian soils contain natural uranium and thorium with concentrations ranging from 0.005 to 0.06 Bq/g.

Glossary

Activity
The number of nuclear disintegrations per second. One becquerel (Bq) is one disintegration per second. The curie (Ci) is the number of disintegrations per second of one gram of pure radium. 1 Ci = 37 GBq; 1 µCi = 3700 Bq. To convert an activity quoted in curies (Ci) to becquerels (Bq), multiply by 3.7 x 1010. E.g. 1 mCi = 37 MBq.

ALARA
As Low As Reasonably Achievable. Use safe procedures to minimise radiation doses. Effective means include use of time, distance, and shielding to reduce radiation exposure.

ARPANSA
Australian Radiation Protection and Nuclear Safety Agency. Australia's primary authority on radiation protection and nuclear safety. Their publication program includes fundamentals, codes, and guides for use of radiation sources.

Australian Safeguards and Non-proliferation Office (ASNO)
National regulator for nuclear material (i.e. plutonium, thorium, uranium).

Naturally Occurring Radioactive Material (NORM)
Materials that exist in the natural environment and contain radionuclides. Long-lived radioactive elements of interest include uranium, thorium, potassium, and their radioactive decay products such as radium and radon.

Radiation project application
An application to the Radiation Safety Committee including project details, risk assessment, and safe work procedures for a specific study involving radiation sources of any kind, including NORM. An application form can be obtained from the RSO.

Radiation Safety Committee (RSC)
The Curtin body appointed to to supervise the performance of the appointed Radiation Safety Officer. The RSC provides guidance to the RSO concerning radiation-related matters and assesses radiation projects with high potential risk.

Radiation Safety Officer (RSO)
The Curtin worker appointed to perform the duties set out in reg. 19(c) of the Radiation Safety (General) Regulations 1983 and other relevant legislation.

Radiation Safety Supervisor (RSS)
A Head of School or Area Manager may nominate a Radiation Safety Supervisor to act on their behalf in matters related to radiation safety in their area.

Radiation worker
A Curtin worker who deals with ionizing radiation. Curtin policy requires that every radiation worker be issued with a personal radiation monitoring device.

Radiological Council
A statutory body appointed under the Radiation Safety Act 1975 to protect public health and maintain safe practices in radiation use.

School
A School, Institute, Discipline, Centre, geographical location, or any other collection of units/locations as agreed by the Head(s) of School with responsibility for resources included therein.

Specific activity
Activity (in Becquerels) divided by mass (in grams). Also called *activity concentration*.

TENORM
Technologically Enhanced Naturally Occurring Radioactive Material is a term that is sometimes used to define naturally occurring radioactive materials that may have experienced some kind of technological enhancement. Human activity can enhance NORM so that its composition, concentration, availability or proximity to people is altered. Whenever the term NORM is used in these guidelines it should be understood to include TENORM, unless specified otherwise.

Waste
Material for which there is no foreseeable use.

Worker
Curtin staff, students, contractors, or visitors.

References

ARPANSA. 2005. *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. Radiation Protection Series 9. Yallambie: ARPANSA.

———. 2008. *Management of Naturally Occurring Radioactive Material (NORM)*. Radiation Protection Series 15. Yallambie: ARPANSA. https://www.arpansa.gov.au/sites/default/files/legacy/pubs/rps/rps15.pdf.

———. 2016. *Radiation Protection in Planned Exposure Situations*. Radiation Protection Series, C-1. Yallambie: ARPANSA. https://www.arpansa.gov.au/sites/default/files/legacy/pubs/rps/rpsc-1.pdf.

———. 2019. *Code for the Safe Transport of Radioactive Material.* Rev. 1. Radiation Protection Series, C-2. Yallambie: ARPANSA.

Cooper, Malcolm B. 2005. "Naturally Occurring Radioactive Materials (NORM) in Australian Industries – Review of Current Inventories and Future Generation."

Laboratory Design and Construction Committee. 2010. *AS/NZS 2982-2010: Laboratory Design and Construction*. Australian Standards Organisation. https://www.standards.org.au/standards-catalogue/sa-snz/building/bd-046-1/{designation}.

National Health and Medical Research Council (Australia). 1993. *Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia*. Canberra: Australian Govt. Pub. Service.

NCRP. 2005. *Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities: Recommendations of the National Council on Radiation Protection and Measurements*. NCRP Report 151. Bethesda, MD: National Council on Radiation Protection; Measurements.

ORISE. n.d. "Radiological and Chemical Properties of Uranium." Accessed February 26, 2020. https://www.nrc.gov/docs/ML1122/ML11227A233.pdf.

US EPA, OAR. 2014. "Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)." Overviews and {Factsheets}. https://www.epa.gov/radiation/technologically-enhanced-naturally-occurring-radioactive-materials-tenorm.

Western Australia. 1975. "Radiation Safety Act." https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_41554.pdf/$FILE/Radiation%20Safety%20Act%201975%20-%20%5B04-c0-01%5D.pdf?OpenElement.

———. 1983. "Radiation Safety (General) Regulations." https://www.legislation.wa.gov.au/legislation/prod/filestore.nsf/FileURL/mrdoc_44743.pdf/$FILE/Radiation%20Safety%20(General)%20Regulations%201983%20-%20%5B04-j0-00%5D.pdf?OpenElement.

World Nuclear Association. 2019. "Naturally Occurring Radioactive Materials (NORM)." https://world-nuclear.org/information-library/safety-and-security/radiation-and-health/naturally-occurring-radioactive-materials-norm.aspx.