RADIATION MANAGEMENT PLAN

Version 9
September 2021

Review History

Date	Sections	Reviewers	Comments
April 2016	All	William Bartolo	Development of RMP
August 2016	All	Deborah Edmunds	Review and comment
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May 2018	All	Melissa Musicka & W Bartolo	Review plus addition
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NOTE: this document (The RMP) complies with ARPANSA RPS 10, C5 and 17 requirements rather than NSW EPA Guideline 2 (2018)

CONTENTS

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RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Introduction, Policy, Responsibilities and Implementation
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EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service
KEY TERMS	Radiation safety, Policy, Responsibility, Implementation, Glossary; How to Use this Manual
SUMMARY *Brief summary of the contents of the document*	The University Radiation Safety Policy and Implementation.

INDEX – Section 1

1. PHILOSOPHY

This University and the Chemical Radiation Technical Committee (CRTC) are totally committed to the principle that underpins modern protection practice, and to ensure at all times that radiation exposure of both occupationally exposed and non-occupationally exposed staff, students and general public to above background ionising and non-ionising radiation is kept:

AS LOW AS REASONABLY ACHIEVABLE
(At acceptable Social and Economic Cost)

All staff and students of University of Newcastle are expected:

- to embrace this philosophy
- to translate As Low As Reasonably Achievable into their activities in relation to the use of radiation within their workplace and laboratories
- act in accordance with the jurisdictional Radiation Safety Legislation and Codes of Practice;
- to adhere to the content of this manual and
- to acknowledge their responsibilities to the general public, their fellow students, workmates and themselves.

NOTE: this document (The RMP) complies with ARPANSA RPS 10, 14 and 17 requirements rather than NSW EPA Guideline 2 (2018)

2. UNIVERSITY POLICY

This document should be read in conjunction with the University's Work Health and Safety Policy and associated documents. These can be found at:

https://www.newcastle.edu.au/__data/assets/pdf_file/0004/273883/Health-and-Safety-Policy.pdf

https://www.newcastle.edu.au/current-staff/our-organisation/governance

3. UNIVERSITY STAFF DISCIPLINARY PROCEDURES

3.1. Staff Disciplinary Procedures

This document should be read in conjunction with the University's Academic Staff Agreement and Professional Staff Agreement. The relevant information can be found at:

https://www.newcastle.edu.au/current-staff/working-here/benefits-and-conditions/enterprise-agreements

3.2. Student Disciplinary Procedures

This document should be read in conjunction with the University's Student Conduct Rule. This information can be found at:

https://policies.newcastle.edu.au/document/view-current.php?id=34

4. GLOSSARY

Absorbed dose	the energy absorbed by matter from ionizing radiation per unit mass of irradiated substance. The SI unit of absorbed dose is the joule per kilogram, with the special name gray (Gy). For radiation protection purposes, the absorbed dose is averaged over a tissue or organ
Accident	any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection and safety.
Activity (with regards to [wrt] radioactivity)	the average number of spontaneous nuclear transformations of a radionuclide occurring in unit time. The SI unit of activity is the becquerel (Bq), which is equal to one nuclear transformation per second
ALARA	As Low As Reasonably Achievable
Annual limit on intake (ALI)	that quantity of a radionuclide which, if taken into the body during one year, would lead to a committed effective dose equal to the relevant annual limit on effective dose
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ARPS	The Australasian Radiation Protection Society
AS1319	Australian Standard 1319 Safety Signs
AS2243.4	Australian Standard 2243.4 Safety in Laboratories: Pt 4 Ionizing Radiation
AS2982	Australian Standard 2982 Laboratory Design & Construction
Becquerel (Bq)	the special name for the SI unit of activity. It is defined as 1 disintegration per second.
Category 1 source	means a sealed radioactive source (or an aggregation of sealed radioactive sources) that is a category 1 source (determined in accordance with Schedule B to the Code).
Category 2 source	means a sealed radioactive source (or an aggregation of sealed radioactive sources) that is a category 2 source (determined in accordance with Schedule B to the Code).
Category 3 source	means a sealed radioactive source (or an aggregation of sealed radioactive sources) that is a category 3 source (determined in accordance with Schedule B to the Code).
CI	Chief Investigator
Committed effective dose, E(τ)	The quantity E(τ), defined as: $E(\tau) = \sum_{T} w_T \times H_T(\tau)$ where $H_T(\tau)$ = the committed equivalent dose to tissue or organ T over the integration time τ elapsed after an intake of radioactive substances w_T = the tissue weighting factor for tissue or organ T When τ is not specified, it will be taken to be 50 years for adults and the time to age 70 years for intakes by children.

Constraint	a prospective and source related value of individual dose (dose constraint) or of individual risk (risk constraint) that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization. The dose constraint for each particular source is intended, among other things, to ensure that the sum of doses from planned operations for all sources under control remains within the dose limit. The risk constraint is a source related value that provides a basic level of protection for the individuals most at risk from a source. This risk is a function of the probability of an unintended event causing a dose and the probability of the detriment due to such a dose. Risk constraints correspond to dose constraints but apply to potential exposure.
COP	Code of Practice
CRE	Certified Radiation Expert
CRTC	University of Newcastle Chemical and Radiation Technical Committee
CT	Computed Tomography
Dealing	manufacture, possess (or have control over), use, operate, process, modify or dispose of an apparatus or material considered as 'controlled' by a relevant regulatory body.
Derived air concentration (DAC) for occupational exposure	the ALI (of a radionuclide) divided by the volume of air inhaled by Reference Man in a working year (i.e. 2.4 X 10^{-3} m^3). The unit of DAC is the becquerel per cubic metre (Bq/m^3).
Deterministic effect	an effect, such as partial loss of function of an organ or tissue, caused by radiation and which occurs only above some threshold of dose, the severity of the effect depending upon the magnitude of the dose received.
DRA	Designated Radiation Area —an area where the occupational exposure of personnel to radiation or radioactive substances is under the supervision of a radiation protection adviser (RPA) [or RSO]
Dose	a generic term which can mean absorbed dose, equivalent dose or effective dose, depending on context.
DVC (R&T)	Deputy Vice Chancellor (Research and Innovation)
Effective dose	the product of the equivalent dose (in a tissue or organ) and the tissue weighting factor (w_T), summed over all the tissues and organs of the body. The SI unit is the joule per kilogram, with the special name sievert (Sv).
Emergency Exposure Situation	an unexpected situation of exposure that arises as a result of an accident, a malicious act, or any other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences.
Environmental Exposure	the exposure of wildlife to ionising radiation. This includes exposure of animals, plants and other organisms in the natural environment.

Environmental Monitoring	the measurement of external dose rates due to sources in the environment or of radionuclide concentrations in environmental media.
EPA	Environmental Protection Authority
Equivalent dose	the product of the absorbed dose (averaged over a tissue or organ) and the radiation weighting factor (wj^) for the radiation that is of interest. The SI unit of equivalent dose is the joule per kilogram, with the special name sievert (Sv).
Glove Box	a closed box with internal pressure not exceeding ambient, having impermeable gloves (for example rubber gloves) and viewing ports in one or more sides, which is used to completely enclose the radioactive substances and the operations on the substances.
Gray (Gy)	the special name for the SI unit of absorbed dose. 1 Gy = 1 J kg^{-1}
Half-life	in relation to radioactive decay, the time required for the quantity of a radionuclide to decrease to one half of its initial value.
HOS	Head of School
HREC	University of Newcastle Human Research Ethics Committee
HSW	Health, Safety and Wellbeing team (HSW)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
Intervention	action taken to decrease exposures to radiation which can arise from existing situations.
Ionising radiation	electromagnetic or particulate radiation capable of producing ions directly or indirectly in passage through matter, but does not include electromagnetic radiation of a wavelength greater than 100 nanometres.
Irradiating apparatus	apparatus that is capable of producing ionizing radiation, or of accelerating atomic particles, for which a registration/licence is required from the appropriate regulatory authority
IRPA	International Radiation Protection Association
Justification (wrt radiation)	The process of determining whether a practice (or intervention) is, overall, beneficial, as required by the International Commission on Radiological Protection's System of Radiological Protection, i.e. whether the benefits to individuals and to society from introducing or continuing the practice outweigh the harm (including radiation detriment) resulting from the practice.
Licence	means a licence (including a temporary licence) in force under section 6 of the NSW Legislation.
LSO	Laser Safety Officer
Monitoring	The measurement of dose, dose rate or activity for reasons relating to the assessment or control of exposure to radiation or exposure due to radioactive substances, and the interpretation of the results.

National Directory	means the national guidance documents titled “National Directory for Radiation Protection” [ARPANSA RPS No.6] approved by the Health Ministers for the States, Territories and Commonwealth from time to time.
NHMRC	National Health and Medical Research Council
Non-ionising radiation	(a) electromagnetic radiation of a wavelength greater than 100 nanometres, or (b) non-varying electric or magnetic fields, or (c) sonic, infrasonic or ultrasonic waves that are prescribed asnon-ionising radiation for the purposes of this definition.
NSW HURSOG	NSW Hospitals and Universities Radiation Safety Officers Group
Occupationally exposed person	a person who, in the course of his or her work, could be exposed to ionizing radiation arising from direct involvement with sources of such radiation.
Occupier	in relation to premises, means: (a) the person in occupation or control of the premises, or (b) if the premises have different parts occupied or controlled by different persons, the person in occupation or control of the part concerned.
OHS	Occupational Health and Safety
Optimization of Protection (and safety)	The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, “as low as reasonably achievable, economic and social factors being taken into account” (ALARA), as required by the International Commission on Radiological Protection System of Radiological Protection.
Owner	in relation to any apparatus or thing that has been leased or let out on hire, means the lessee or the person who takes it on hire; for radiation producing items that is the Radiation Management License Holder..
POEA	Protection of the Environment Administration legislation
POEO	Protection of the Environment Operations legislation
QA	Quality Assurance
QAP	Quality Assurance Program
Radiation apparatus	means a manufactured or assembled article, or any component, part or accessory of such an article, which when in operation contains or acts as part of an electrical circuit, or which acts by electromagnetic amplification employing a resonant space, and emits (or in the absence of effective shielding or other control would emit) ionising or non-ionising radiation.
Radiation Laboratory	a laboratory in which irradiating apparatus or sealed radioactive sources are used or stored. It does not contain any unsealed radioactive substances.
Radiation User Licence	The Radiation User Licence will be a licence solely for the purpose of the use of radioactive substances or ionising equipment. This licence **does not give** the holder of such a licence the authority to purchase, own, dispose, loan, control storage, transfer radioactive materials or ionising equipment, or approve projects.

Radioactive ore	means an ore or mineral containing more than the concentration of uranium or thorium prescribed for the purposes of this definition.
Radioactive substance	means any natural or artificial substance whether in solid or liquid form or in the form of a gas or vapour (including any article or compound whether it has or has not been subjected to any artificial treatment or process) which emits ionising radiation spontaneously with a specific activity greater than the prescribed amount and which consists of or contains more than the prescribed activity of any radioactive element whether natural or artificial.
Radioisotope Laboratory	a laboratory in which an unsealed radioactive substance is used or stored. It does not contain any irradiating apparatus.
Radiological Hazard	the potential danger to health arising from exposure to ionizing radiation; it can arise from external radiation or from radiation emitted by radioactive substances within the body.
Radiological Laboratory	a laboratory which incorporates the functions of both a radiation laboratory and a radioisotope laboratory.
R&I	Research & Innovation Division
RML	Radiation Management License as issued by the NSW EPA
RMP	Radiation Management Plan
RPA	Radiation Protection Adviser - a person appointed by the management/employer wherever radioactive substances are used in amounts that require licensing, or wherever irradiating apparatus is used (and has the qualifications and experience to be such)
RPS	Radiation Protection Series – ARPANSA publications
RSO	Radiation Safety Officer
RSC	Radiation Safety Committee
Radiotoxicity	the toxicity attributable to ionizing radiation emitted by a radionuclide (and its decay products) incorporated in the human body. Radiotoxicity is related not only to the radioactive characteristics of the radionuclide but also to its chemical and physical state and to the metabolism of the radioactive elements in the bodyor in an organ of the body.
Sealed radioactive source	means a radioactive substance sealed in a capsule, or closely bound in a solid form, so as: (a) to prevent escape or dispersion of the radioactive substance, and (b) to allow the emission of ionising radiation.
Sealed source device	means equipment or a gauge, instrument or device that contains a sealed radioactive source and permits the controlled emission of radiation, but does not include a container used solely forthe storage or transport of a sealed radioactive source.
SI	*Système international d'unités* – The international system of units

Sievert (Sv)	the special name of the SI unit for both equivalent dose and effective dose. 1 S v = 1 J kg^{-l}
SOP	Standard Operating Procedures
Stochastic effect	an effect known to occur sometimes as a consequence of exposure to radiation, but which may or may not occur in a particular exposed person, the likelihood of the effect occurring being a function of the dose received. NOTE: Examples are carcinogenesis in exposed individuals and hereditary effects in the descendants of exposed individuals
Unsealed source	a source which is not a sealed source and which under normal conditions of use can produce contamination
Weighting Factor	*Radiation weighting factor (w*R) — A number by which the absorbed dose in a tissue or organ is multiplied to reflect the relative biological effectiveness of the radiation in inducing stochastic effects at low doses, the result being the equivalent dose. *Tissue weighting factor (w*T)— Multiplier of the equivalent dose to an organ or tissue used for radiation protection purposes to account for the different sensitivities of different organs and tissues to the induction of stochastic effects of radiation.
WHS	Work Health and Safety

5. GENERAL RESPONSIBILITIES

5.1 Licensing

There are two types of licences under the NSW legislation. The University is the Radiation Management Licence holder and radiation workers are required to hold an appropriate Radiation User Licence for the use of radioactive substances or ionising equipment.

For staff information and details an example of the University RML is included at the end of this Radiation Management Plan.

5.2 Radiation Management License

As described in the Act and Regulations, the Radiation Management License has the responsibility for:

- The Radiation Management Plan
- all purchases/acquisitions of isotopes and ionising equipment,
- all ownership of isotopes and ionising equipment
- control of user license applications (that is research and teaching using radiation) at the institute
- control of all sources (sealed and unsealed) and ionising equipment including registrations

- storage,
- security,
- Reporting annually to EPA (covering isotopes both sealed and unsealed, equipment and facilities, and possibly users)
- Records/documentation, and
- Disposal and trade of all radioactive substances and ionising equipment.

There will only be one RML for the University based on the University's ABN.

5.3 Radiation User License

The User License will be a license solely for the purpose of the use if radioactive substances or ionising equipment. This license **does not give** the holder of such a license the authority to:

- Purchase or trade or give away or loan any radiation (isotopes or equipment)
- Own radioisotopes or ionising equipment
- Possess, organise or manage storage as part of their license conditions
- Dispose
- Trade
- Develop local SOP's and procedures if they are employed by a company or institute.

There are also conditions attached to such licences, as set by the EPA.

User Licence holders will be required, by not only the Conditions of Licence that will be applied, but also by the condition that they are working under the requirements of the Radiation Management Licence and the Radiation Management Plan to (including but not exclusive):

- Comply with all the requirements of the Radiation Management Plan
- Comply with any directions from the RSO or H&S (as the direct delegates of the RML holder)
- Ensure radiation safety in their workplace
- Complete all documentation as is required in the legislation and in the RMP
- Supply the University with a copy of their licence, and any other relevant documentation so requested
- And any other matter or process as is required by legislation, mandated codes of practice and the Radiation Management Plan

6. HOW TO USE THIS MANAGEMENT PLAN

Not every section of this Radiation Management Plan is applicable to all users of radiation.

Appendix 1.1 has a flow diagram to assist University of Newcastle staff and students in what sections they would need to refer for a number of radiation use situations.

7. DOCUMENTATION –

None

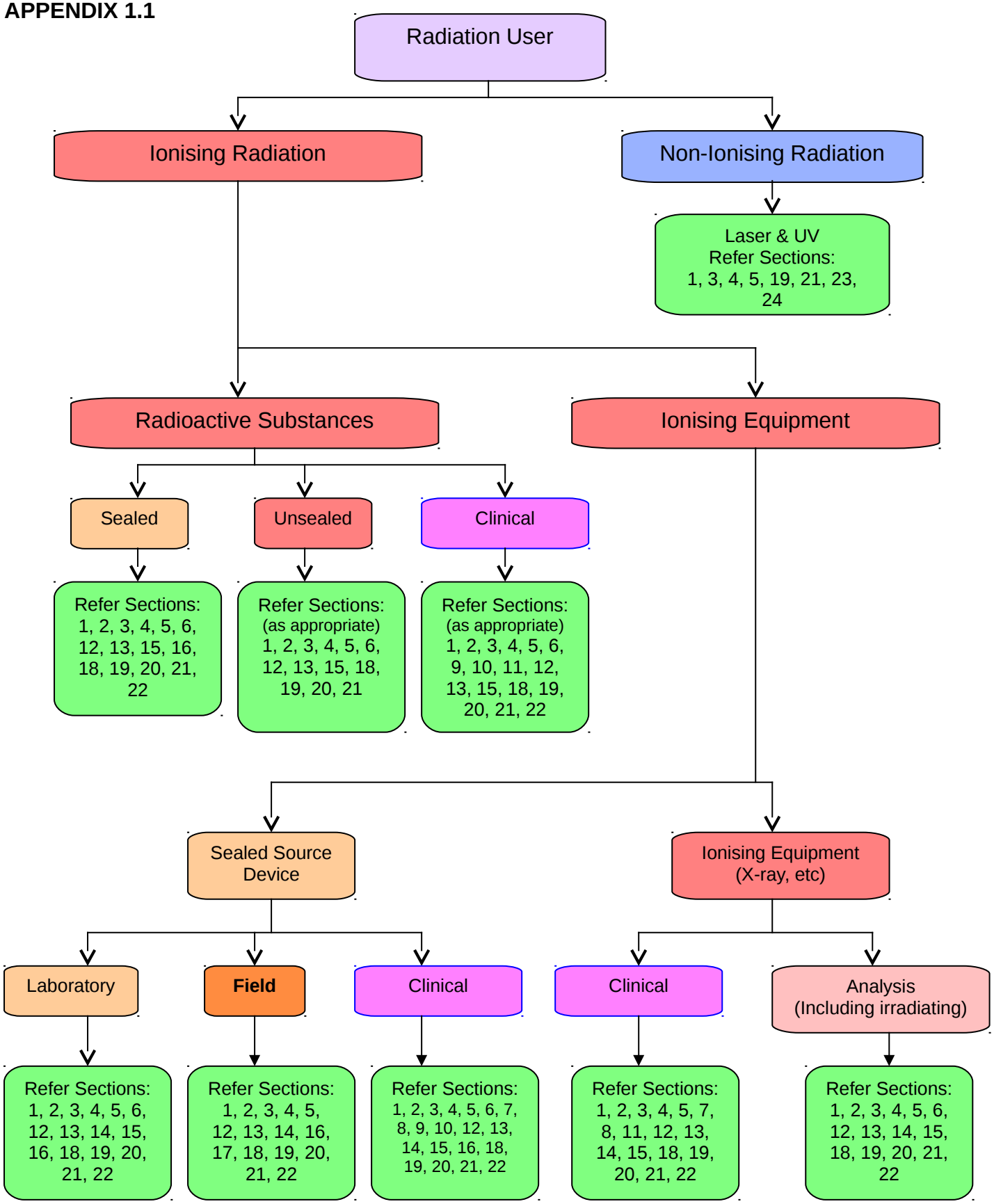
8. AUDIT

None

9. REVISION & APPROVAL HISTORY

Date	Revision No.	Author and Approval
Jan., 2016	draft	William Bartolo, Bartolo Safety Management Service
Mar., 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Oct, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC & William Bartolo
Mar., 2018	Revision 6	Ms M Musicka & William Bartolo
May, 2018	Revision 8	Ms M Musicka & William Bartolo
Sept., 2021	Revision 9	Ms M Musicka & William Bartolo

APPENDIX 1.1



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RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation exposure and risk
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Background Information for Radiation Users
DOCUMENT NUMBER	RMP-S2
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service
KEY TERMS	Radiation safety, ionising radiation, risk
SUMMARY *Brief summary of the contents of the document*	Information on the nature of radiation, the sources of radiation and the risks associated with radiation exposure.

INDEX – Section 2

1. BACKGROUND INFORMATION

In order to comply with policy it is necessary to understand the nature of radiation, the sources of radiation and the risks associated with radiation exposure. This document provides this information and the objectives of radiation protection.

SI units will be used throughout the documents

2. IONISING RADIATION

2.1. Types of Ionising Radiation

Ionisation is any process by which an atom or molecule gains an electric charge by the removal of an electron. Any radiation which is capable of causing this effect is known as ionising radiation. This differs from non-ionising radiations such as that produced by lasers, UV-lights, mobile phones and microwave ovens.

In terms of teaching and research environments, ionising radiations emitted from radioactive atoms or produced by x-ray sources include:

Alpha (α) particles

These are identical with helium nuclei, having two protons and two neutrons. Alpha particles are usually emitted by heavy radioactive atoms such as uranium and radium. Being large and relatively slow, they quickly dissipate their energy by colliding with the atoms of the material through which they travel causing ionisation to take place. Alpha particles thus have very little power of penetration and are stopped completely by a thin sheet of paper, the outer layer of human skin, or a few centimetres of air. Alpha emitters are most damaging when incorporated into the body, and are not normally used unless securely sealed. However there is an increasing interest in their use as therapeutic agents when they are directed specifically to the target cells.

Beta (β) particles

These are high speed electrons emitted from the nuclei of radioactive atoms. Being light weight, and emitted with a speed approaching that of light, beta particles have greater penetrating ability than alpha particles of the same energy, but still will be stopped by a few millimetres of aluminium, a centimetre or so of human tissue or a few metres of air, dependent on their energy. Beta emitters are also most hazardous when ingested, but can also be hazardous, externally, especially to the cornea. Beta emitters are often administered as therapeutic agents.

Positrons (β^+)

These have the same mass as an electron but carry a positive charge instead of a negative charge. They have the same properties as beta particles however they eventually combine with an electron which results in the emission of 2 gamma rays. Radioactive substances which emit positrons are used in positron emission tomography (PET scans).

Gamma (γ) rays

These are electromagnetic radiations of the same family as visible light, and travel at the same speed. They have a high penetrating power and can pass through several hundreds of metres

of air or many centimetres of dense materials such as iron or lead. Gamma emitters are hazardous internally and externally, although less damaging than the particle sources.

X-rays

These are physically identical to gamma rays and differ only in their means of production, which is usually by means of electrons striking a dense material as occurs in a common diagnostic X-ray machine.

Neutrons

These are subatomic particles with no net electric charge and a mass slightly larger than that of a proton. They can be used to measure the concentrations of elements (a technique known as neutron activation analysis) and can be a safety concern in certain applications when the high energy X-rays can produce neutrons in the shielding material.

2.2. Radiation Units and Quantities

Energy (eV)

The energy of particles or rays is expressed in electron volts (eV). An electron volt is the energy acquired by an electron when accelerated by a potential difference of one volt. Since this is a very small amount of energy, we usually talk in terms of keV and MeV, ie. kilo or mega electron volts.

Exposure (C/Kg)

This unit measures the amount of ionisation produced in air by a given radiation source. It is measured in coulombs per kilogram of air at normal temperature and pressure and is directly related to the number of radioactive particles or gamma rays per unit area incident on a given body of mass. Exposure is easily and accurately measured.

Absorbed Dose (gray, Gy)

This unit measures the amount of energy deposited per unit mass of material by ionising radiation. One gray is the amount of radiation which will deposit one Joule per kilogram of energy in a specified material. The gray is a very large unit and most radiation dose, outside of radiation therapeutic doses, are likely to lay in the milligray (mGy) or microgray (µGy) regions. Note that the tissue or material involved must also be specified along with the absorbed dose.

For example, a chest X-ray gives about 200 µGy to the chest wall, while a radiotherapy treatment may involve 60 Gy (300,000 times as much as the chest X-ray).

Equivalent Dose (sievert, Sv)

This unit is a measure of the biological effect produced, for equal energy absorption, by different types of radiation. The relation between equivalent dose and absorbed dose is given by:

$$\text{Equivalent dose} = \text{absorbed dose} \times W_R$$

where W_R, the radiation weighting factor, is dependent on the type of radiation. For most radiation encountered in the hospital environment W_R is nearly equal to 1, so that equivalent dose often is numerically equal to absorbed dose. The sievert is a large unit and most equivalent doses will be in the millisievert (mSv) and microsievert (µSv) range.

Effective Dose (sievert, Sv)

When a number of tissues or organs are irradiated to different absorbed doses, the biological effect cannot be described simply by equivalent dose, as different organs have varying sensitivities to radiation. In this case, effective dose is used, and is calculated as the sum of the equivalent dose to each irradiated organ multiplied by what is called the tissue weighting factor W_T. That is :

$$\text{Effective dose} = \sum^{\text{all irradiated organs}} \text{equivalent dose} \times W_T$$

Activity (becquerel, Bq)

The radioactivity of a given radioactive source is measured in terms of the number of radioactive disintegrations per second occurring in that source. The unit of radioactivity is the becquerel (Bq) which is the activity of a source giving rise to 1 disintegration per second. Every disintegration is associated with the emission of ionising radiation. The becquerel is a very small unit, and the usual activities encountered in University facilities are in the kilobecquerel (kBq) megabecquerel (MBq) or gigabecquerel (GBq) range.

The specific activity is the activity of a sample divided by its mass (Bq/g).

The activity concentration is the activity of a sample divided by its volume (Bq/m^3 or Bq/ml)

Half-Life

The half-life of a radioactive substance is the time taken for the substance to reach half of its original activity; that is for the disintegration rate to reduce to half its original value. This is known as the physical half-life, in contrast to the biological half-life of a material which refers to the time taken for half an administered substance to be excreted by the body, this value having nothing to do with radiation.

The **effective half-life** (T_E) is a term used to describe the amount of time taken for the body to remove half of the original introduced activity utilising both the physical (T_p) and biological (T_B) half lives, and is given by the relationship:

$$T_E^{-1} = T_P^{-1} + T_B^{-1}$$

Or

$$T_E = \frac{T_P \times T_B}{T_P + T_B}$$

2.3. Sources of radiation exposure (including background)

There are a number of possible situations:

- exposure may be experienced in the workplace (occupational exposure), by members of the public (general exposure), or by patients/volunteers (medical/research exposure). Only occupational and general exposures are limited by regulations.
- the nature of the exposure may be intentional or accidental.

The majority of the average annual radiation dose to the population is from natural sources of radiation. In Australia, the background radiation dose equivalent is of the order of 2-2.5 mSv. The sources of this radiation are many and varied (see Fig. 2.1), but the greatest component is natural radon, which arises from the decay of trace amounts of uranium in the ground. Urban areas in Australia have generally low radon levels, but in some parts of the world such as Cornwall in the UK, radon levels may be very high.

Cosmic radiation arises mainly from the sun, and increases quickly with altitude above sea level, since the earth's atmosphere is a natural radiation shield. Latitude is also important, the levels increasing as the poles are approached.

Radiation from food and drink is, in the southern hemisphere, entirely natural, and thus almost impossible to reduce. Medical sources are the greatest man-made component of background.

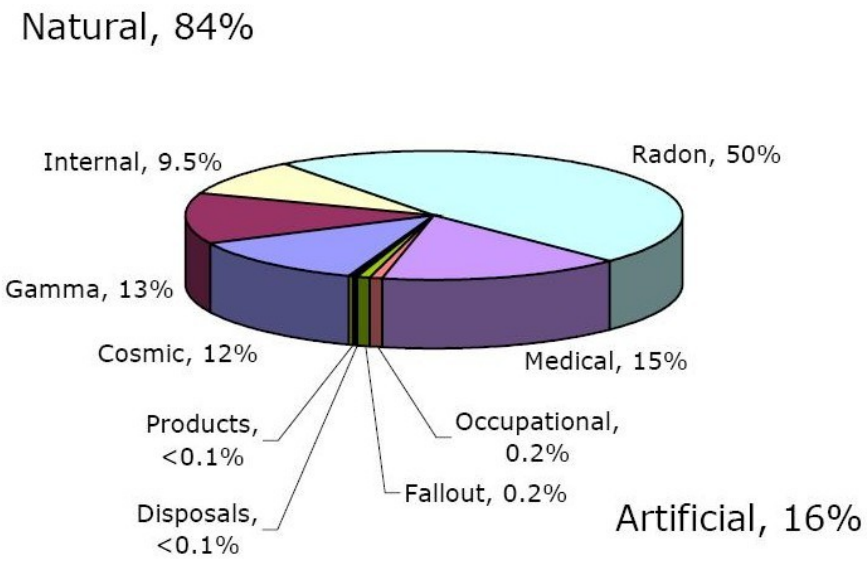


Fig. 2.1 - Average Annual Radiation Dose to the Population

Source: NRPB (UK) 2005

(Note: The section labelled "Gamma" is due to naturally occurring terrestrial sources, such as granite, mineral sands or other radioactive materials in the soil)

3. RISKS ASSOCIATED WITH RADIATION EXPOSURE

Evaluation of the risks involved due to exposure to ionising radiation is a very complex problem. Most estimates have been extrapolated from data obtained on groups of persons receiving relatively high doses (such as the victims of the Hiroshima and Nagasaki atomic bombs). These estimates assume a linear dose effect relationship down to zero dose. For example, the risks in Table 2.1 below represent the overall fatal cancer risk to the whole population.

Table 2.1 - Risks due to radiation assuming no threshold dose

Tissue or Organ Irradiated	Risk per mGy	
Active bone marrow (Leukaemia)	3.8×10^{-6}	1 in 260,000
Bladder	2.3×10^{-6}	1 in 430,000
Bone surface	0.5×10^{-6}	1 in 2,000,000
Lung	11.3×10^{-6}	1 in 88,000
Breast (females)	6.2×10^{-6}	1 in 160,000
Thyroid	1.0×10^{-6}	1 in 1,000,000
Skin	4×10^{-6}	1 in 250,000
Stomach	7.7×10^{-6}	1 in 130,000
Colon	4.9×10^{-6}	1 in 200,000
Oesophagus	1.5×10^{-6}	1 in 660,000
Liver	3.0×10^{-6}	1 in 330,000
Ovary (females)	0.9×10^{-6}	1 in 1,100,000
Total cancer risk	**56×10^{-6}**	**1 in 18,000**
Severe hereditary disorders (all generations)	1.9×10^{-6}	1 in 525,000
Baseline cancer mortality from all other causes	0.15 – 0.25	1 in 4 – 1 in 6

(ref. ICRP 103)

In order to put the above risk in perspective, risks of death of 1 in 1 million from various causes are compared in Table 2.2, but the public perception of risk can be very different.

Table 2 Comparative risks associated with a risk of death of 1 in 1 million

Scenario	Cause of Death
Travelling 100 miles by car	Accident
Travelling 1000 miles by jet aircraft	Accident
Travelling 10 miles by bicycle	Accident
Travelling 6 minutes by canoe	Accident
Spending 2 days in Sydney CBD	Air pollution
Smoking 1.4 cigarettes	Cancer, heart disease
Eating 40 tablespoons of peanut butter	Liver cancer
Spending 1 hour in a coal mine	Pneumoconiosis
Living for 150 years within 20 miles of a nuclear power plant	Radiation-induced cancer
Receiving 0.1 mSv of radiation	cancer

** Majority of information taken from W.A. Govt. 2009 Mine Safety Road Show*

4. OBJECTIVES OF RADIATION PROTECTION

Radiation effects are divided into two groups:

- stochastic effects
- deterministic effects

In **stochastic** effects, the probability (but not the severity) of occurrence is related to the magnitude of the dose, without threshold. An example is cancer induction. A small dose will give you a small probability of getting cancer, and a larger dose, a larger probability - however the severity of the cancer is the same in both cases. Hereditary effects are also stochastic. It is highly probable that small doses of radiation carry zero risk (or could even be beneficial). However, for protection purposes, a conservative approach is taken.

With **deterministic** effects, there is a threshold below which the effect does not occur. Beyond this threshold the severity of the effect is related to the dose. An example is a radiation skin burn - a small dose will not produce a burn, a very large dose will, and the larger the dose the worse the burn.

The objective of radiation protection is to prevent harmful deterministic effects, and to limit the occurrence of stochastic effects to acceptable levels.

This objective is achieved by a philosophy based on

- **justification** for any radiation exposure, and

- **optimisation** of any dose to the lowest possible levels (As Low as Reasonably Achievable" - the ALARA principle), and
- setting **limits** to the equivalent dose (not including natural or medical radiation) which can be received in any year by workers and the general public.

Dose limits are treated as just that, and not a permitted maximum.

For patients/volunteers, the lowest radiation dose is that which provides the diagnostic information, or research data.

The occupational dose limits are set by the International Commission on Radiological Protection and have been incorporated into the ARPANSA Codes and thus the NSW Radiation Control Regulation.

5. THE USES OF RADIATION AND RADIOACTIVITY WITHIN UNIVERSITY OF NEWCASTLE

University of Newcastle has several facilities that use ionising radiation, ranging from research radioisotope laboratories to clinical facilities with one X-ray machine. The facilities may use any combination of the following:

Diagnostic radiology.
This process uses radiation generating apparatus for diagnostic imaging of a patient. Typical equipment is plane x-ray machines, CT machines, fluoroscopy machines and dental X-ray machines to produce an internal image of a patient. Bone mineral densitometry and mammography also utilise x-rays.

Magnetic resonance imaging and ultrasonography do not use ionising radiation and do not present a radiation hazard to the patient or to the staff.

Analytical radiology.
This is the use of x-rays to diagnose chemical, mineral and physical structures. For example crystal structures can be analysed using X-ray crystallography or diffraction equipment.

Laboratories.
Some laboratories use unsealed radioactive substances in radioimmunoassays or as tracers when studying how different materials move through biological or other systems, or for chemical analysis.

Sample Irradiation.
This process uses high activity sealed sources or high powered linear accelerators to provide extremely large doses of radiation to a sample.

6. DOCUMENTATION

None

7 AUDIT

None

8. REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Dec 2013	draft	William Bartolo, Bartolo Safety Management Service
Sept., 2015	revised draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Oct, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC & William Bartolo
Dec, 2017	Revision 6	Ms M Musicka & William Bartolo
May, 2017	Revision 8	Ms M Musicka & William Bartolo
Sept., 2021	Revision 9	Ms M Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	REGULATORY REQUIREMENTS
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure and information for users
DOCUMENT NUMBER	RMP – S3
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of three years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service Bartolo-safety@hotkey.net.au
KEY TERMS	Regulatory requirements, dose, dose constraints, dose limits, registration requirements, licensing requirements, penalties
SUMMARY *Brief summary of the contents of the document*	Procedures to ensure that all staff, students and visitors at University of Newcastle involved in the occupational use of radiation are informed of radiation specific regulations.

INDEX – Section 3

1. BACKGROUND

To maintain a Radiation Management License (RML), the radiation management licence holder and any staff, students or visitors working under that licence must comply with various regulatory requirements that govern the possession, use and exposure of individuals and the environment to ionising radiation. As part of this the radiation management licence holder and any staff, students or visitors working under that licence must ensure that all staff, students and visitors at University of Newcastle involved in the use of ionising radiation are aware and comply with the statutory requirements.

2. GENERAL PROCEDURES

2.1. All uses of radiation (radiation apparatus and radioactive substances) must have Safety Approval before any activities pertaining to the radiation can be carried out. This includes purchase.

2.2. The HSW (Health, Safety and Wellbeing) Team of the University will keep and maintain a Central Radiation Register, which will include records of:

2.2.1. all diagnostic radiation apparatus, sealed source devices including soil moisture gauge, X-ray analysis equipment and premises in which radioactive substances are kept or used.

2.2.2. the corresponding Registration Number issued by the EPA for each item or premises and their corresponding conditions of use

2.2.3. user licences including expiry dates and conditions of the licences.

2.2.4. time and methods of disposal and or decommissioning of such items

2.3. The University will submit any changes to the register to the EPA.

2.4. If any item listed on the radiation register is to be altered, moved (except portable equipment being used in accordance with the approved protocol) or disposed of, it will require written notification and approval by HSW Team, which will notify the EPA.

2.5. Before a sealed source within a sealed source device is changed the HSW (Health, Safety and Wellbeing) Team must be notified, and approval given by the University CRTC.

RESPONSIBILITIES

For a Radiation Project Application to be approved, the University is responsible to ensure that:

2.6. all staff, students and visitors at University of Newcastle involved in the occupational use of ionising radiation have access to and have understood the appropriate acts, and regulations;

2.7. the applications must demonstrate how all staff, students and visitors at University of Newcastle involved in the occupational use of ionising radiation will comply with the regulatory requirements; and

2.8. Any person carrying out work involving radiation apparatus or radioactive substances must hold a current user licence with the appropriate conditions to carry out such work, or have been issued with an exemption approval in writing and working under the direction and supervision of a person holding such a user licence.

REGULATORY REQUIREMENTS

2.9. Legislation and Codes of Practice

In NSW all uses of radiation are governed by the Radiation Control Act 1990 (2010) and the Radiation Control Regulation 2013.

These are administered by the NSW EPA.

The Act allows for the adoption of documents forming part of the National Directory for Radiation Protection (via ARPANSA under the Federal ARPANS Act 1998). The following documents have been gazetted in NSW for such adoption and are relevant to this Radiation Management Plan:

- ARPANSA RPS C-1 (Rev. 1):Code for Radiation Protection in Planned Exposure Situations (2020)
- RPS C5 Code for Radiation Protection in Medical Exposure
- RPS 5 Portable Density/Moisture Gauges containing Radioactive Sources
- RPS 6 National Directory of Radiation Protection
- RPS 8 Code of Practice for Exposure of Humans to Ionizing Radiation for Research Purposes
- RPS 10 Radiation Protection in Dentistry
- RPS 11 Code of Practice for the Security of Radioactive Sources
- RPS 17 Radiation Protection in Veterinary Medicine *(not gazetted but being listed as condition of license)*

In addition, the following three Safety Guides are available to assist in meeting the requirements of RPS 14.

- RPS 14.1 Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology
- RPS 14.2 Safety Guide for Radiation Protection in Nuclear Medicine
- RPS 14.3 Safety Guide for Radiation Protection in Radiotherapy

Additionally, federal legislation administered by the *Australian Safeguards and Non-Proliferation Office* (ASNO) has precedence on some items e.g. uranyl products.

3. OVERVIEW OF LEGISLATIVE REQUIREMENTS AND GUIDELINES PERTENANT TO APPROVAL OF A RADIATION SAFETY AND BIOSAFETY APPLICATION

3.1. Occupational Dose Limits

All staff, students and visitors at University of Newcastle who are exposed to ionising radiation as part of their employment or studentship are deemed to be occupationally exposed, and therefore are subject to radiation dose limits as described in Schedule 2 of the Radiation Control Regulation (**see Appendix 3.1** of this Section). Note that these limits apply to occupational and public exposure only, and not to exposures received as part of medical diagnosis or treatment.

Females, Pregnancy and Age

The basis for the control of occupational exposure is the same for women as for men, except that if and when a pregnancy is declared by a female employee, the embryo or foetus should be afforded the same level of protection as is required for a member of the public. This may be achieved by controlling the exposure of an employee who declares a pregnancy in a manner which ensures that doses which may be received by the foetus during the remainder of the pregnancy while the employee is at work are consistent with the public effective dose limit given in Appendix 3.1.

Persons under the age of 16 should not be exposed to radiation occupationally and should be treated as members of the public for radiation protection purposes.

3.2. Dose Constraints

A dose constraint is usually set at a value lower than the corresponding dose limit and is used for planning purposes to ensure that the dose limit is not exceeded.

The EPA has specified the following design dose constraints when radiation shielding is being designed, assessed or verified in Radiation Guideline 7:

- 100 µSv per week for occupationally exposed persons from all sources of radiation, and
- 20 µSv per week for members of the general public.

3.3. Registration Requirements and any Special Conditions for the Radiation Apparatus or Radioactive Sources to be used

If you are unsure as to whether or not an item needs to be registered then first consult the Radiation Control Regulation and then the HSW Team for confirmation.

Contact the HSW Team in regards to registrations.

For staff information and details an example of the University RML is included at the end of this Radiation Management Plan.

3.4. User Licensing Requirements for Staff using Radiation Apparatus or Radioactive Substances

Any person carrying out work involving radiation apparatus or radioactive substances must hold a current user licence with the appropriate conditions to carry out such work, or have been issued with an exemption approval in writing and working under the direction and supervision of a person holding such a user licence. The EPA issues such licences to suitably qualified persons and has the power to withdraw or withhold licences when deemed necessary. A separate user licence condition is required for radiation apparatus and for radioactive substances.

Possession of a user licence implies responsibility of the licensee to ensure that the conditions of the user licence are met, that persons working under his/her supervision carry out their work in a safe manner in accordance with written conditions contained in the exemption approval, and that the licensee complies with any local requirements so listed or detailed in the Radiation Management Plan, or imposed by the University CRTC.

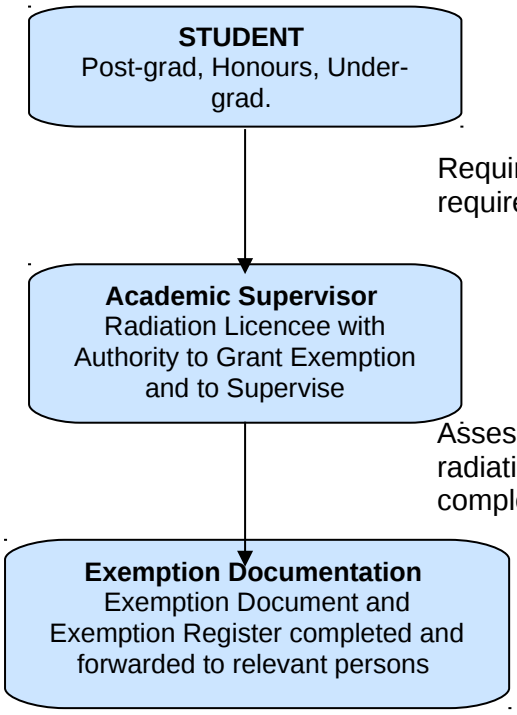
Failure to comply with the requirements of the Radiation Control Act and its associated subordinate legislative documents such as the Radiation Control Regulation and licence conditions, can result in penalties in the form of fines, imprisonment or both. These penalties are applicable to both individuals and the University.

Licence applications can be completed at the NSW EPA website Radiation Licence applications. Licences are renewable on either an annual or 3-yearly basis, and a copy of the renewed document should be passed to the HSW Team who maintains the University's records.

You may obtain details of licence conditions, and exemptions and supervision requirements via EPA web link, or contact the HSW Team if you need further details.

A radiation licence is not required for staff who are present when radiation apparatus or radioactive substances are used, but do not control the radiation exposure in any way.

3.5. Licence Exemption Procedures – Students only



For an Exemption to be granted the following needs to be ensured:

- ONLY STUDENTS, as deemed under Part 2, Clause 9 of the Radiation Control Regulations (NSW) 2013, may be granted an exemption by an appropriate licensee
- The exemption must be in writing using the form in **Appendix 3.2**
- The exemption document must specify the radioactive substances or irradiating apparatus
- The exemption must set out the conditions to which the exemption is subject (viz., the class or course, the designated radiation area (DRA) or laboratory in which the work must be done, the times during which the work is allowed, etc)

- The exemption must identify each student, or class of students, to whom it relates
- The exemption must identify the appropriately licensed person or persons who are to supervise each student, or class of students, to whom it relates
- The exempting licencee must ensure that a copy of the exemption:
  - ⇒ is given to each student to whom it relates,
  - ⇒ is conspicuously displayed at each place in which the radioactive substances or irradiating apparatus to which the exemption relates are proposed to be used, and
  - ⇒ a copy is kept for the local records(School/Centre level)
- Exemptions must be reviewed and renewed annually.

NOTE: Dentistry and Oral Health Hygiene STUDENTS are exempt from licensing if they have completed the student registration with the Australian Health Practitioner Regulation Agency (AHPRA).

NOTE: AHPRA registration DOES NOT grant an exemption or licence to use Orthopantomogram (OPG) equipment. A NSW EPA issued licence is required, or an exemption granted by a GE1 licence holder. Students are then to be supervised directly while using intra-oral or OPG apparatus, noting the following about potential supervisors as advised by the NSW EPA:

- Dental practitioners registered with AHPRA automatically have a licence to use intra-oral apparatus AND to supervise students using this apparatus.
- Holders of an IA20 licence to operate OPG apparatus are also automatically able to supervise students and do not require any additional licensing for this role.

DOCUMENTATION

None

AUDIT

Every 2 years

REVISION & APPROVAL HISTORY

Date	Revision No.	Author and Approval
December 2013	draft	William Bartolo, Bartolo Safety Management Service
Sept., 2015	revised draft	William Bartolo, Bartolo Safety Management Service
March 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Oct, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC & William Bartolo
May, 2019	Revision 8	Ms M Musicka & William Bartolo
Sept., 2021	Revision 9	Ms M Musicka & William Bartolo

Appendix 3.1

OCCUPATIONAL AND PUBLIC DOSE LIMITS[1]

Application	Dose limit		
	Occupational (18 years and over) [1]	**Public** [6]	**more than 16 years but under 18 years** [1,5]
Effective dose (see Note 2)	20 mSv per year, averaged over 5 consecutive years (see Note 2	1 mSv in a year (see Note 7)	6 mSv per year
Annual equivalent dose in: Lens of the eye Skin (see Note 3) Hands and feet	 20 mSv (see Note 3) 500 mSv 500 mSv	 15 mSv 50 mSv —	 20 mSv per year 150 mSv per year 150 mSv per year

Notes:

1. The limits apply to the sum of the relevant doses from external exposure in the specified period and the 50-year committed dose from intakes in the same period.
2. With the further provision that the effective dose must not exceed 50 mSv in any single year. When a pregnancy is declared by an occupationally exposed female, the working conditions of that person should be such as to ensure that the additional dose to the embryo/foetus would not exceed about 1 mSv during the remainder of the pregnancy.
3. With the further provision that the equivalent dose must not exceed 50 mSv in any single year.
4. The equivalent dose limit for the skin applies to the dose averaged over 1 cm^2 of the most highly irradiated area of the skin. The dose to the skin also contributes to the effective dose, this contribution being the average dose to the entire skin multiplied by the tissue weighting factor for the skin.
5. Persons under the age of 16 years must not be subject to occupational exposure. Persons under the age of 18 but more than 16 years must not be subject to occupational exposure unless they are under supervision and only for the purpose of training for employment or for the purpose of studies in which sources are used
6. The limits 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.
7. In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over five years does not exceed 1 mSv per year.

Appendix 3.2

University of Newcastle

Student Exemption to the Radiation Licensing Requirements of the Radiation Control Act (NSW) 1990

I, ……., Radiation License Number , ……..

(Who has the appropriate endorsement on their license to grant exemptions) hereby give approval to

……., an under/postgraduate student [or insert class of persons to be granted exemption] at the University of Newcastle enrolled in the course of

……,

undertaking the subject ……(Code & Name), for use of the radionuclide …… or

irradiating apparatus ……

in the ……laboratory, as directed in the practical sections of the above subject for the …….. semester.

The supervisor for this person/these persons shall be ……

License No. (has the appropriate endorsement for supervision) ……...

(Optional) This approval is subject to the following conditions:

Signed …… Date ……

NOTE: This exemption is for a 12 month period only and is applicable to students only

A copy of this exemption must be:

- filed locally
- given to the student
- displayed in the radiation facility
- sent to the University RSA via Liz.Pilgrim@Newcastle.edu.au

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Purchase, Acquisition and Storage
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S4
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA[RSO] Bartolo Safety Management Service Bartolo-safety@hotkey.net.au
KEY TERMS	Radiation Purchase, Radiation Acquisition, Storage of Radiation Emitting materials
SUMMARY *Brief summary of the contents of the document*	Information on the Procedures for the purchase and acquisition of Ionising substances and equipment and the storage requirements for such items.

INDEX – Section 4

1. BACKGROUND

The Radiation Management Licence Holder (the Deputy Vice Chancellor Research & Innovation delegated to the Associate Director, Employee Relations and Work, Health and Safety) has the sole responsibility for the purchase of all radioactive substances, uranyl salts, sealed source devises, and ionising equipment.

The Radiation Management Licence Holder (the Deputy Vice Chancellor Research & Innovation) has the sole responsibility for the storage and disposal of all radioactive substances, uranyl salts, sealed source devises, and ionising equipment.

No holder of a user license can:

- purchase, acquire by borrowing or trading or changing ownership of radiation (radioactive substance, sealed source devises, and ionising equipment).
- organise, form or control any storage facility for radiation
- dispose of radiation (radioactive substance, sealed source devices, and ionising equipment.

2. ACQUISITION PROCEDURE

This procedure also applies to acquisition by borrowing and gifting. The Radiation Purchase Approval form (see Appendix 4.1 of this Section) must be completed for all proposed purchase/acquisitions of radiation equipment or radioactive nuclides, uranyl salts and must be sent to the Health and Safety Team (safetyclearance@newcastle.edu.au) for approval prior to the purchase proceeding.

The form (see Appendix 4.1 of this Section) will contain:

- Purchaser information
- user licence details
- the CRTC approval number
- name of the substance and amount and/or equipment to be purchased
- the supplier details
- import licence number (if applicable)
- information about storage and disposal

3. STORAGE PROCEDURE

- The RML holder will be responsible for approving and keeping and maintaining a record of all forms of storage for radiation including rooms, cupboards and fridges.
- HSW will organise, inspect, approve, and ensure the integrity of storage facilities.
- HSW will ensure an inventory is conducted at a minimum of every 6 months of the storage facility.
- Refer to RMP Section 18 in regards to radioactive waste storage.

Access to such storage will be restricted and be a part of the initial CRTC approval process. Any subsequent changes to access will require an amendment to the CRTC approval with the local management maintaining a copy of this amendment.

4. **DOCUMENTATION**

Application to acquire documentation

5. **AUDIT**

Every 2 years

6. **REVISION AND APPROVAL HISTORY** *(state the author of the document, the date it was written, and its revision number and approval history)*

Date	Revision No.	Author and Approval
January,2014	draft	William Bartolo, Bartolo Safety Management Service
Sept., 2015	revised draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Oct, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC & William Bartolo
Dec, 2017	Revision 6	Ms M Musicka & William Bartolo
June, 2018	Revision 7	Ms M Musicka
May, 2019	Revision 8	Ms M Musicka & William Bartolo
Sept., 2021	Revision 9	Ms M Musicka & William Bartolo

APPENDIX 4.1

Application for approval to purchase a radiation source or apparatus

Section A	
Project (Identify the project/activity that includes the use of this source/apparatus)	
Project or Activity Title	
Safety Review Reference Number (if applicable)	
CI/Supervisor:	
Contact Person:	
School/college	
Summary (to be completed if purchase does not fall under a research project or teaching activity)	
Please provide an overview of the requirement for this purchase	

Section B	
Location the source or apparatus will be stored/situated	
Campus/Site	
Building Name	
Room Number	
Additional info can be recorded here (location in the room etc)	
Who is the responsible supervisor of the space and have they approved the purchase and installation?	
Does the facility meet the required quality, safety, security and any other compliance requirements for the purposes of storing/housing/handling/operating this source/apparatus?	
List Personnel who will be handling/operating this source/apparatus	

PTO for Sections C & D

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RADIATION MANAGEMENT PLAN COVER SHEET

Section C	
Identify the Source/equipment to be purchased (include all relevant details- brand/manufacturer, total activity (Bq)*, model number etc. and whether the purchase covers/includes disposal costs)	
Radioisotopes/unsealed sources (excluding below)	.
TC99M Generator (size in Bq/number of generators per yr)	
Ionising Radiation Instrument/Sealed Source eg x-ray	
Non-ionising radiation eg. Laser, RF-heating, microwaves, sonic, MRI	

*** Total activity for isotope purchases over one year**

Section D	
Purchasing Information	
Supplier (name and address)	
Supplier Contact person **Name:** **Phone:** **Email Address:**	

Office Use Only:
Date Application Received: / /
This purchase has been approved for The University of Newcastle Signed---------- Date---------- Deputy Vice Chancellor (Research and Innovation) Radiation Management Licence:

Once completed this form should be submitted to **safetyclearance@newcastle.edu.au** for processing.

The applicant will be notified and if approved, the authorised form will be forwarded to the supplier (contact noted in Section D) confirming the purchase/s have been approved to proceed under the University Radiation Management License within the next 12 months from the date above.

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Project Approval (Teaching and Research)
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S5
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RSO Bartolo Safety Management Service Bartolo-safety@hotkey.net.au
KEY TERMS	Radiation Approval, Project Approval, Project Safety Management
SUMMARY *Brief summary of the contents of the document*	Information on the Procedures for the approval application process before radiation acquisition or use occurs.

INDEX – Section 5

1. BACKGROUND

To comply with legislation before commencing any research or teaching involving radiation (materials or ionising equipment – this includes sealed and unsealed isotope sources + Uranyl salts, XRD/F analysis equipment, clinical x-ray, ionising equipment and lasers), it must first be approved by the Radiation Management License Holder or his/her delegate. In this case, it is the University of Newcastle CRTC.

This process enables the Radiation Management License Holder (DVC R&I) (or delegate) to document and maintain control of radiation management for approved research or teaching using radiation so that it complies with legislation.

2. RESPONSIBILITIES

- If anything goes awry, the legal responsibility will be shared between the **RML holder** and the user licensee who has completed the application documentation.
- **The CRTC** is responsible for approving the project and ensuring that all personnel have had the appropriate training.
- **Chief Investigator/Responsible Academic/Subject Coordinator**: This person will be responsible for ensuring that all aspects of the project are adhered to in accordance to the approved proposal. This includes ensuring that anyone working on the project adheres to the approved project proposal. They are also responsible for ensuring that any changes to the protocol are first approved by the CRTC. This includes adding additional students or researchers to the project and changes to the protocol(s).

3. PROCEDURE

Applications to use radiation in teaching or research activities associated with the University must be made to the CRTC using the approved form.

In the case of a University of Newcastle staff member using radiation at another institution or university, the person requesting to use the radiation must demonstrate to the University of Newcastle CRTC that they have gained approval by the equivalent committee or person in the other organisation.

Note:

- The University of Newcastle CRTC submission deadlines and meeting times are published on the University of Newcastle Website.
- It is advisable to consult with HSW, the CRTC and/or the University of Newcastle radiation safety officer (RSO) whilst preparing the application.

DOCUMENTATION

Application form (Safety Review form https://www.newcastle.edu.au/current-staff/teaching-and-research/health-and-safety-for-teaching-and-research/risk-assessments-for-teaching-and-research. This will eventually be replaced by tick@lab.

The application form will be reviewed by the CRTC and HSW as required. The latest versions of the form will always be available online at the above URL. The Chief Investigator or Subject Coordinator is responsible for submitting a variation to the Safety Approval if the legislation changes or if there are any variations required to the approved proposal.

AUDIT

Every 2 years

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Dec., 2014	Draft 1	William Bartolo, Bartolo Safety Management Service
March 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Oct, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC & William Bartolo
Dec, 2017	Revision 6	Ms M Musicka & William Bartolo
June, 2018	Revision 7	Ms M Musicka
May, 2019	Revision 8	Ms M Musicka & William Bartolo
Nov., 2021	Revision 9	Ms M Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Safety in Laboratories and Monitoring
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S6
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service Bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, X-rays, radioactive substances, laboratory safety
SUMMARY *Brief summary of the contents of the document*	Procedures to limit the risk to health of staff arising from exposure to radiation from laboratory use of radioactive substances or X-ray devices.

INDEX – Section 6

1. BACKGROUND

Workers involved in laboratory procedures involving radioactive substances may be exposed externally to radiation from the source (mainly beta and gamma radiation) but may also be exposed internally if any of the radionuclide is inhaled or ingested. Radio-isotopes can also enter the body through open cuts. Hence high standards of laboratory cleanliness and good laboratory techniques will minimise the likelihood of radioactive contamination.

2. RESPONSIBILITIES

2.1. HSW/University of Newcastle CRTC

HSW and the University of Newcastle CRTC will ensure that the radiation laboratory, associated facilities, equipment and training are compliant with current regulations, the RMP and approved project proposal.

HSW and the CRTC will oversee and provide advice on radiation safety within laboratories using radioactive substances and/or ionising radiation apparatus, e.g. X-ray equipment. HSW and the CRTC will be acting on behalf of the RML holder and will have the authority to make immediate adjustments to procedures, to immediately require a procedure to cease or to shut down a facility.

2.2. The Radiation Safety Officer/Radiation Protection Adviser

The RPA [RSO] will monitor and provide advice on radiation safety within laboratories using radioactive substances and/or X-ray apparatus. The RPA/RSO will have the authority to make immediate adjustments to procedures, or to immediately require a procedure to cease, or to shut down a facility.

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Chief Investigator

The Chief Investigator is responsible for ensuring that all projects involving radiation have been approved by the CRTC, that all procedures are performed safely and that all personnel working on the project are:

- Appropriately trained (including specific training in radiation safety and emergency procedures) and licensed or license exempted where necessary;
- Aware of the requirements of the RMP; and
- Issued with and wear personal radiation monitors where necessary;
- Issued with and wear PPE identified as required in the safety approval, SOP or risk assessment.

Subject Coordinator/Responsible Academic

The Subject Coordinator is responsible for ensuring that a teaching subject involving the use of radiation has been approved by the CRTC, that all procedures are performed safely and that all personnel working on the subject are:

- Appropriately trained (including specific training in radiation safety and emergency procedures) and licensed or license exempted where necessary;
- Aware of the requirements of the RMP; and
- Issued with and wear personal radiation monitors where necessary;
- Issued with and wear PPE identified as required in the safety approval, SOP or risk assessment.

The Subject Coordinator must ensure that all personnel working on the subject are aware of, and comply with, these procedures.

Personnel working on the project

Personnel will perform all procedures in accordance with the CRTC project approval, relevant SOP, risk assessment and the RMP.

3. PROCEDURE

3.1. Procedures for the safe handling of unsealed sources of radioactivity

3.1.1. Unsealed source procedures are to be conducted in an appropriate and registered facility (see RMP Section 15).

Note: a substance is only considered to be radioactive if its specific activity is at or exceeds 100 Bq/g and is deemed to require licensing if the total activity exceeds the thresholds listed in Schedule 1 of the Radiation Control Regulation. If a laboratory's occupants are using substances with activities below this threshold (e.g. < 400 kBq of I-125 in a radio-iodination lab), the lab still needs to be registered.

3.1.2. When using unsealed radioactive sources, care should be taken where possible to minimise internal and external contamination. Internal contamination may result from inhalation, ingestion, skin wounds or skin penetration. Note: No unsealed radioactive sources should be manipulated with unprotected hands. Gloves should always be worn. ^{14}C on the skin may be absorbed into the body at a rate of 0.3% per minute (18% per hour). ^{3}H (as tritiated water) may be absorbed through the skin at a rate of up to 23% per minute. Radionuclides of iodine, such as ^{125}I and ^{131}I can be volatile and should be handled in a fume cupboard.

3.1.3. It should be remembered that penetration of gloves may occur when handling some iodine compounds. A second pair of gloves is thus recommended.

3.1.4. Gloves should be removed in the proper surgical manner (remove one glove, hold in the other hand and fold the second glove over the first) and disposed of correctly after use, to avoid contamination of hands.

3.1.5. A laboratory coat or gown must be worn and must be buttoned up when handling radioactivity. (It is preferable to use yellow disposable lab coats)

3.1.6. Mouth pipetting of any substance including radioactive substance is totally prohibited.

3.1.7. Precautions should be taken to avoid punctures, cuts and any open skin wounds.

3.1.8. Cover all working surfaces with protective absorbent paper and clearly mark the area as a radiation working area. Lab grade plastic backed benchcover “underpad” is particularly suitable for this purpose.

3.1.9. Wash hands thoroughly after using radionuclides.

3.1.10. Pure beta emitters such as ^{32}P and ^{35}S should be handled whilst standing behind a protective barrier made of a low atomic number material such as Perspex.

3.1.11. Radionuclides which emit gamma rays, such as ^{131}I, will require shielding with lead.

3.1.12. Food, beverages, smoking items, handbags, cosmetics, handkerchiefs and eating and drinking utensils are prohibited in all laboratories including where unsealed sources are used.

3.1.13. Food and drinks must never be stored in a refrigerator or freezer designated for radioactive materials.

3.1.14. Contain waste appropriately and immediately.

3.1.15. Be familiar with decontamination and radiation monitoring procedures.

3.1.16. Use only self adhesive labels in radiation working areas.

3.1.17. Monitor radiation exposure by:

3.1.17.1. wearing a body personal radiation monitor and/or finger monitors if appropriate

3.1.17.2. periodic thyroid counting after performing iodinations

3.1.17.3. self-monitoring using a portable detector for radioactive contamination after working with unsealed sources.

3.1.18. At the end of each procedure the area should be completely cleaned and checked for any contamination.

3.1.19. All containers must be clearly labelled with the name of the radionuclide, its chemical form, and activity, along with the measurement time and date. If the material is sterile, this must be clearly indicated. The name of the responsible person should also appear on the label.

3.1.20. All containers of radioactive material must be adequately shielded at all times.

3.1.21. For activities of greater than 50 MBq, the container must never be directly handled. Remote handling devices, such as tongs, must be used instead.

3.1.22. Non-radioactive work, particularly record keeping, must not be performed in the area designated for radioactive work. A designated clean write up area should be clearly sign posted and must be separate from bench space used for lab work. Equipment manuals, decontamination and contamination testing records, copies

of student exemptions, lab usage record/log and a register of isotopes stored in the lab should be kept in this area.

3.1.23. Glassware, forceps, scissors and other instruments for use with radioactivity should be marked as such, and not removed from the area.

3.1.24. Maintenance work to fixtures and plant should be carried out only after the Radiation Safety Officer has given clearance.

3.1.25. No new procedures involving radioactive substances are to be commenced until the Radiation Safety Officer has been consulted with regard to radiation safety.

3.2. Personal protective equipment

3.2.1. Protective clothing reserved specifically for radioactive work, shall be worn at all times in the laboratory, even for very low levels of activity. The following should apply:

3.2.1.1. A disposable yellow gown with elasticized sleeve cuffs will be worn.

3.2.1.2. In high level laboratories, in addition to the yellow gown with elasticized sleeve cuffs coats, overshoes or similar, specially designated footwear shall be worn to prevent the transfer of radioactive contamination from laboratory floors.

3.2.1.3. Suitable gloves (double gloving) shall be worn for all work with unsealed radioactive substances, and special care is to be exercised when putting on or removing gloves, to avoid contaminating the hands and the inside surfaces of the gloves.

3.2.1.4. Suitable eye protection must be worn at all times whilst in the Designated Radiation Area (the laboratory).

3.2.2. Paper towels will be used for drying hands after washing. Air dryers may not be used. Paper towels used for drying hands are to be discarded as active waste.

3.2.3. All protective clothing worn in radioisotope and radiological laboratories shall be removed before leaving, and left in, or immediately outside, the laboratory; the latter place shall then be regarded as an ‘active’ area, i.e. possessing a potential contamination hazard. Contaminated protective clothing shall not be laundered with uncontaminated items. NB: Recommended disposable lab gowns be used.

4. Emergency procedures

4.1. Spills of radioactive material are not to be regarded as an unavoidable hazard in the day-to-day operation of the department. Any spill has a degree of risk and acceptance of minor spills could lead to a casual approach to major spills. Accidents involving radioactive material must be reported to the HSW Team via the incident reporting system (AIMS).

The following procedure should be followed on discovery of a contamination problem:

4.1.1. Accidents involving radioactive material must be reported to the University of Newcastle HSW Team.

4.1.2. All persons involved in the incident are to vacate the immediate vicinity but are not to move freely around the department, as this involves a danger of spreading contamination.

4.1.3. IMMEDIATELY notify the person responsible for radiation safety in the laboratory and the University HSW Team (who will contact the University Radiation Safety Adviser.

4.1.4. If the contamination is due to a container spill of liquid and the hands are protected with gloves, right the container and ensure that it is adequately shielded. If the problem is due to a leaky container, place suspect item in a labelled plastic bag.

4.1.5. Seal off the area involved and in particular ensure that personnel do not walk on any potentially contaminated floor area. Discard any clothing which is contaminated and place it in a labelled plastic bag.

4.1.6. Consult with Radiation Safety Officer to determine disposal of bags and waste items

4.2. Incidents involving contaminated or exposed persons - Refer to RMP Section 19

5. X-ray Diffraction and Fluoroscopy Safety

The following requirements have been extracted from current Codes of Practice, Guidelines and Regulations and include:

- Locating shielding as close as practicable to the source of radiation. Precautions should be taken to protect laboratory workers and persons in adjacent areas from direct and scattered radiation.
- Indicator warning lights
- Development of Safety Procedures
- Training
- Interlocks
- Placarding of DRA's (designated radiation areas)
- Monitoring

5.1. General Working Rules for all X-Ray Analysis Units

5.1.1. Each person who uses an X-ray analysis unit shall avoid exposing any part of the body to a primary X-ray beam.

5.1.2. No person shall allow the X-ray tube of an X-ray analysis unit to remain energised unless all warning lights, as required by this Code, are operating correctly.

5.1.3. No X-ray tube shall be energised:

5.1.4. while outside its protective tube housing, or

5.1.5. with an unshielded aperture in the tube head or protective barrier.

5.1.6. No sample, collimator, monochromator or analysing crystal shall be changed or adjusted while a primary X-ray beam passes through that collimator or is incident on that sample or crystal unless:

5.1.7. the sample, collimator, monochromator or crystal, during and after the change or adjustment, is within a shielded enclosure, and

5.1.8. the change or adjustment is done by remote means from outside the enclosure.

5.1.9. Immediate measures shall be taken to remove potentially hazardous situations arising from X-ray beams that may be emitted due to equipment defect, misalignment or any other reason.

5.1.10. A list of additional working rules shall be drawn up for each X-ray analysis unit where necessary to ensure safety. This is of particular importance for units which do not meet the requirements of the ARPANSA (1984) Code for enclosed or partly enclosed units.

5.1.11. The necessary operations of the X-ray analysis equipment shall not be performed by inexperienced persons unless under direct supervision of an experienced operator.

5.1.12. Alignments or adjustments shall not be carried out visually while the X-ray tube is energized, unless a viewing system is used which is shielded or designed to prevent exposure of the eye or other parts of the body to the primary beam.

5.1.13. The X-ray analysis unit shall not be operated, by inactivation of an interlock or with part of its enclosure removed without prior approval of the statutory authority or unless the X-ray tube is wholly enclosed by the tube housing with all apertures completely covered by interlocked shutters and/or fixed covers.

5.2. Safety Guidelines for Enclosed Installations (NHMRC/ARPANSA)

User responsibilities that must be adopted

The user shall be responsible for the safe use of the X-ray analysis equipment at all times and shall ensure that:

- all legislative requirements are satisfied;
- all safety features required are implemented and are regularly serviced and maintained in good working order;
- the requirements outlined in this safety manual are completed and maintained;
- no X-ray analysis unit is operated while a safety feature is removed, modified or inactivated except under the approval of the Government Authority;

- in the case of an actual or suspected exposure to the intense primary beam, the persons involved are referred for medical examination, medical reports are retained, and full details of the incident are reported to the statutory authority as soon as possible (within 7 days of the incident by law);

- the signs required are prominently located and are maintained in a clean, intact and legible state;

Each operator of an X-ray analysis unit shall:

- at all times carry out established procedures of operation and maintenance, and
- report to the RSO any actual or suspected case of excessive exposure, endeavour to determine its cause, and take steps to prevent its recurrence.

5.3. Safety Guidelines for Partially Enclosed & Open Installations (NHMRC/ARPANSA)

For units that do not meet the requirements of enclosed apparatus then more stringent controls and requirements are to be implemented. Partly enclosed units which incorporate fixed shields and/or barriers shall be designed to give a clear and positive warning if the barriers or shields are incomplete. A clear and unambiguous notice shall also be displayed on or near the unit indicating the hazards of operating the unit while barriers or shields are incomplete.

Each partly enclosed unit shall satisfy the relevant requirements for enclosed units plus the following additional requirements:

5.3.1. It shall be so constructed that it incorporates an enclosure or enclosures which partly enclose the primary X-ray beams sufficiently to ensure that no person may inadvertently expose any part of their body to a primary beam. The enclosure shall:

5.3.1.1. be interlocked, or fixed so as to require the use of tools for removal.

5.3.1.2. incorporate collimator shields, and

5.3.1.3. contain appropriate shielding material or be located at a sufficient distance from the X-ray tube that the dose of radiation at any accessible point five centimetres from the surface of each partial enclosure shall not exceed 25 μGy in one hour.

5.3.2. It should be so sited that if for any reason a shutter is opened while an entrance to an enclosure is uncovered or barriers are incomplete, the resultant primary beam is directed away from areas that may be occupied. If such siting is not possible, beam stops or fixed shields shall be placed to adequately protect persons in these areas from the beam.

5.3.3. **It should be sited in a separate room or cubicle in which there are no other radiation sources.**

5.3.4. It should be so constructed that all operations are most easily and quickly carried out with all shields in place and all interlocks in operation.

5.4. Non Complying X-Ray Units

Each X-ray analysis unit which does not comply with (i.e. does not meet the requirements for an enclosed or partly enclosed unit) shall not be used until modified to meet those requirements, unless the user has prior approval of the statutory authority to do so for an interim period. When such approval is given a set of working rules approved by the statutory authority shall be drawn up for use pending the required modifications or replacement by a unit that complies. These working rules shall be designed to achieve the same standard of safety as the required modifications of the equipment, shall be prominently displayed on or near the X-ray analysis unit, and shall be rigorously implemented. The interim working rules shall include rules and requirements as follows:

5.4.1. The rules required for partly enclosed units shall be included, and implemented whenever the unit is used.

5.4.2. Supplementary interim rules shall be included to minimize the risk that any person will be exposed to a primary X-ray beam from the unit or otherwise receive a dose of radiation in excess of the recommended dose limit.

5.4.3. A check-list of step-by-step procedures shall be prepared and used during the following operations:

5.4.3.1. before initiating an exposure

5.4.3.2. during an exposure

5.4.3.3. in terminating an exposure, and

5.4.3.4. during any non-routine operation of the unit, such as alignment of an X-ray beam.

5.4.4. The unit shall not be operated if any person other than those essential to its operation occupies the cubicle, room or area in which the unit is placed.

5.4.5. No alteration should be made to the analysing equipment in use with the unit unless the X-ray tube is de-energised.

5.4.6. Interim working rules shall include the requirements for siting given in the previous sections, with the requirement 'should' being replaced by 'shall'.

5.4.7. The requirements of the following section (radiation monitoring) shall be incorporated in the working rules with the following amendments:

5.4.7.1. The requirement 'should' in personal monitoring shall be replaced by 'shall'.

5.4.7.2. Periodical monitoring shall be performed not less than once in each month and the unit shall be thoroughly examined for hazards and all safety features checked at least once in each week. This requirement is the same as that for a partly enclosed unit.

6. RADIATION MONITORING

Monitoring, where appropriate, includes the measurement of doses received by laboratory workers, external dose rates in the laboratory, amount of radioactive contamination on surfaces and articles in the laboratory, and radioactive contamination in the air and in effluents. The radiation monitoring program must be documented and should be reviewed periodically and amended in the light of operational experience.

The type and degree of monitoring required depends on the circumstances and the level of exposure. When assessed doses are well below the dose limits, group or area monitoring strategies may suffice.

Workers in laboratories where radioactive substances or sources of ionizing radiation are used shall have ready access to radiation monitoring equipment as specified by the RPA/RSO. In particular, at least one appropriate contamination monitor shall be available for every laboratory where unsealed radioactive substances are used. If high activity sources (sealed or unsealed), or irradiating apparatus could give rise to an external radiation hazard, a dose-rate monitor shall be available.

The advice of the RPA/RSO shall be obtained—

(i) on the type and characteristics of the radiation and contamination monitors required for the unsealed radionuclide work proposed or being carried out; and

(ii) whether a radiation monitor is required, and if so, the appropriate type for work with sealed radionuclide sources or irradiating apparatus.

Further information and advice on the choice of suitable instruments may be obtained from the RPA/RSO.

6.1. PERSONAL MONITORING

Individual personal monitoring shall be implemented when required by the regulatory authority or as advised by the RPA/RSO.

The type and degree of monitoring required depends on the circumstances and the level of exposure. Any estimate to assess the level of exposure should take into account the potential exposure in an unplanned incident situation.

For any worker who regularly works in a Supervised DRA or who enters a Controlled DRA only occasionally, it may be appropriate to assess the occupational exposure on the basis of the results of workplace monitoring or individual monitoring.

For any worker who usually works in a Radiation Controlled area, or who occasionally works in a Radiation Controlled area and may receive a significant dose from occupational exposure, individual monitoring should be undertaken

where appropriate, adequate and feasible. Individual personal monitoring may use of any one, or a combination of, whole body dosimeter, extremity dosimeters, direct reading personal dosimeters, personal air samplers, whole body monitoring and biological monitoring as appropriate.

The aim of personal monitoring is to ensure that the doses received by the individual are kept within those listed in Appendix 1 of RMP Section 3, and any dose constraints so applied by the institute of the RPA/RSO.

Continuous personal monitoring of external dose should be performed by a dosimetry service accepted by the regulatory body. For controlling individual exposure on a day to day basis, or during a particular task, it may be necessary to use supplementary dosimeters of the direct reading type (active dosimeters). If a worker is liable to receive an equivalent dose to the extremities, skin or lens of the eye that is a sizeable fraction of the relevant dose limit, these tissues and organs should be monitored separately.

Where sudden unexpected increases in exposure might result in a significant dose being received by a worker, provision should be made for the continuous monitoring of dose rate using an instrument fitted with appropriate audio and/or visual alarms to warn of unacceptable conditions.

If there is a possibility of exposure to unsealed radioactive substances, a level of activity concentration in air or intake of radioactivity into the body should be established to be used as an indication of whether there is a potential for a significant individual exposure. If this level is exceeded, the RPA/RSO will advise on measurement procedures to be implemented, including additional direct measurements of the individual's internal exposure (for example, thyroid monitoring of persons working with radio-iodine, or urinalysis for persons working with soluble radionuclides).

In cases where individual monitoring of the worker is inappropriate, inadequate or not feasible, the occupational exposure should be assessed on the basis of the results of workplace monitoring and information on the locations and durations of exposure of the worker.

6.2. AREA MONITORING

6.2.1. External radiation

The purpose of area monitoring for external exposure is to identify any areas where appreciable dose rates exist, or where changes have occurred, so that appropriate action, such as provision of shielding or restriction of working time, may be taken to reduce the radiation exposure to personnel. Monitoring instruments may be fixed or portable.

6.2.2. Surface contamination

Work with unsealed radioactive material creates the potential for contamination of surfaces. Regular and frequent contamination monitoring is needed to identify the presence of surface contamination and prevent the inadvertent transfer of such contamination at levels exceeding specified values under normal operating conditions (either the values in AS/NZ 2243.4 Table B2 or 4 Bq/cm^2).

For further information on surface contamination monitoring techniques, see RMP Section 12.

Components comprising or being close to the targets of heavy particle accelerators or close to high activity neutron sources should be checked for induced radioactivity before handling.

6.2.3. Airborne contamination

Airborne contamination can occur in laboratories. If operations involving radioactive substances might produce airborne radioactive contamination in the breathing zone, then the work should be performed in a fume cupboard or glove box. If this is not feasible, some form of air monitoring shall be instituted as advised by the RPA/RSO.

6.3. Radiation Monitoring in Association with X-ray analysis Equipment

Radiation monitoring is an essential aid in the control of radiation hazards in the vicinity of X-ray analysis units and radioactive materials. **However**, with X-ray analysis units the accurate measurement of radiation from these units is often difficult and a person seeking to do such measurement needs specialized equipment, careful technique, and an understanding of the principles involved. The performance of measurements following an accidental exposure of a person to a primary beam is important as a realistic assessment of the dose received is needed to assist in the prediction and treatment of radiation injury. However, radiation monitoring required during use of X-ray analysis units need not be as accurate. In this case simple measurements directed towards prevention of exposure to primary beams and reduction of leakage and scattered radiation to suitably low levels are adequate. The following rules should apply:

- Accurate measurements of radiation exposure or dose, or their rates, in primary, scattered or leakage beams should only be attempted by, or under the supervision of, a person competent to perform such measurements.
- Accurate measurements of leakage and scattered radiation should only be attempted if difficulty is encountered in ensuring the radiation levels are well below the requirements of legislation and guidelines.

Personal Monitoring and X-ray analysis Equipment

Localized personal monitors are usually inadequate indicators of exposure to the narrow beams of radiation which may be emitted from X-ray analysis units. However, personal

monitors have been found useful in the discovery of some cases of exposure of persons to primary beams from X-ray analysis units and in the assessment of whole body dose due to exposure of leakage and scattered radiation from such units. This will only be appropriate for open and semi-enclosed X-ray units.

Monitoring of Equipment for X-ray analysis Equipment

The user of each X-ray analysis unit shall ensure that regular radiation monitoring of the unit is carried out to detect unintended radiation emissions and to assist in preventing such emissions. The following requirements shall apply to such radiation monitoring:

Each instrument used for dose rate monitoring shall comply with the following requirements:

- Its sensitivity shall be adequate to give a positive indication with a time response of not more than 20 seconds for a true dose rate of 10µGy h^{-1} when measured in a field of radiation uniform over the sensitive volume of the detector and having an effective energy within the range of the unit
- If provided with meter indication, the meter shall be either:
  - calibrated in arbitrary units only, and the appropriate method of conversion from these units to exposure rate or dose rate for a radiation field uniform over the sensitive volume of the detector indicated on the instrument, or
  - calibrated in units of exposure rate or dose rate, with a statement clearly displayed on the instrument that its calibration is correct only for a radiation field uniform over the sensitive volume of the detector.
- Each of these radiation surveys shall be conducted with the X-ray tube of the analysis unit operated at the maximum rated voltage and the maximum rated current for that voltage, and with no filtration in the primary beams other than the inherent filtration.
- Periodical radiation monitoring shall be carried out on each X-ray analysis unit that is operated on a regular basis. The frequency of monitoring should be not less than that given in the following schedule, but some variation of this schedule may be warranted with certain units or periods of use:
-

Type of Unit	*Frequency of Monitoring*
Enclosed	*Quarterly*
Partly Enclosed	*Monthly*

NOTE: These times are for infrequently used research units.

DOCUMENTATION

AUDIT

Every 2 years

REFERENCES

NHMRC (now by ARPANSA) RHS No.9: Code of practice for protection against ionising radiation emitted from X-ray analysis equipment (1984).

NHMRC (now by ARPANSA) RHS No.21: Revised statement on cabinet X-ray equipment for examination of letters, packages, baggage, freight and other articles for security, quality control and other purposes (1987).

NHMRC (now by ARPANSA) RHS No.22: Statement on enclosed X-ray equipment for special applications (1987).

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INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Safety in Radiology (Human and Veterinary)
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S7
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LEVEL OF EVIDENCE	
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FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service Bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, X-rays, radiology, medical imaging, Veterinary imaging, PPE, lead aprons, protective clothing, Dentistry
SUMMARY *Brief summary of the contents of the document*	Procedures to limit the risk to health of staff and members of the public arising from exposure to radiation from diagnostic radiology at any facility at the University or associated with the University.

INDEX – Section 7

1. BACKGROUND

Any research involving radiological diagnostic procedures must have a Radiation Medical Practitioner (Radiologist or Medical Specialist for human research; veterinarian or veterinary radiologist for animal research) as a named investigator on the project, unless the work has been contracted out to a licensed provider.

Personnel involved in diagnostic or interventional radiology procedures could receive a radiation exposure principally from scattered radiation from the volunteer, animal or patient being examined. In normal circumstances no one, other than the volunteer, animal or patient, should be exposed to the primary X-ray beam, but such exposure could occur unintentionally.

Members of the public (for example, the mother of a paediatric volunteer or patient) may need to be in an Imaging Room while a diagnostic or interventional radiology procedure is taking place and could also receive a radiation exposure.

University personnel or members of the public in adjoining areas will be adequately protected as long as the required radiation shielding has been installed as required in RMP Section 15.

In addition, a medical physicist is required to provide Human Research Ethics and Animal Ethics Committees with a radiation dose estimation and risk assessment for any research studies that involve the research subjects receiving an exposure from ionizing radiation, for humans in accordance with the requirements of RPS8 (ARPANSA 2005) .

2. RESPONSIBILITIES

2.1. The Radiation Medical Practitioner (Radiologist or Medical Specialist) or Veterinarian or Veterinary Radiologist for animal research

The above named person is responsible for the clinical management of the volunteer, animal or patient undergoing a diagnostic or interventional radiology procedure. This includes the decision to proceed with a radiology procedure based on the specialist's knowledge of the potential risks and benefits of the procedure, taking into account the clinical information, and the sensitivity and specificity of the procedure. For volunteers, they need to ensure that the proposed procedures are compatible with the medical status of the volunteer including pregnancy.

2.2. The Referrer

The referrer of the patient for a research diagnostic procedure needs to be satisfied that the procedure is justified being aware that the patient will receive a radiation exposure. The referral[1] must state the clinical question that the diagnostic procedure is intended to answer and the research reason for this exposure. The referral should also alert the radiation medical practitioner when the referrer is aware that a female patient is pregnant or is breast-feeding.

[1] The referral may be in hard copy or electronic form.

2.3. The Radiographer

The radiographer is responsible for performing diagnostic radiology procedures as prescribed by the radiation medical researcher or practitioner in accordance with the University's written standard protocols.

This will include:

- correctly identifying the volunteer or patient, the procedure and the site to be examined;
- following established imaging protocols to ensure optimal data acquisition and analysis;
- performing quality assurance procedures for instrumentation and image quality.

2.4. The Radiology Medical Physicist

A radiology medical physicist is required to assess, verify and approve the research procedure and is to be readily available for consultation (in person, by phone or through the internet) on optimisation of medical exposures, including clinical dosimetry and quality assurance, and to give advice on matters relating to radiation protection.

The radiology medical physicist works closely with the radiologists and radiographers in the optimisation of clinical studies – through image acquisition, analysis and display optimisation and ongoing oversight of the quality control of equipment.

In addition, a medical physicist is required to provide Human Research Ethics and Animal Ethics Committees with a radiation dose estimation and risk assessment for any research studies that involve the research subjects receiving an exposure from ionizing radiation, in accordance with the requirements of RPS8 (ARPANSA 2005).

2.5. The Radiation Safety Officer

The RPA [RSO] will monitor and provide advice on radiation safety within facilities performing diagnostic or interventional radiology.

3. PROCEDURE

3.1. Procedures to minimise radiation exposure

The radiation dose to the operator or a member of the public can be minimised by prudent positioning relative to the X-ray tube, patient and/or structural shielding. Where there is no structural shield and the operator has to remain in the room during general radiography, such as with mobile radiography, the operator should stand:

- at least two metres away from the X-ray tube;
- and outside the primary beam.

In these circumstances the operator should, wear protective aprons.

Where a person is required to be present in a controlled area during an X-ray exposure, such as in a fluoroscopy suite, that person should not remain any closer to the patient or the X-ray tube than is necessary. The operator should ensure that any person who is required to remain in the room during the radiation exposure wears protective clothing or stands behind protective shields.

The design of all radiology suites should include a protected area in which the operator's console is located. The operator's console should be the only area within the radiology suite that radiography and remote controlled fluoroscopy systems (usually over-table X-ray tube systems) are operable.

3.2. Personal protective equipment

Aprons[2], thyroid shields and other personal protective devices should meet the requirements of the **EPA Policy on x-ray protective clothing**. From *NSW Policy on x-ray protection clothing*: A1.1.4 Aprons must cover the full width of the front of the body from the throat to within 10 cm of the knees, as well as the sides of the body. Wrap-around types of aprons must cover from the shoulder blades to below the buttocks. Fastenings must be provided to keep aprons closed.1 Refer to part A3 for different types of x-ray protective clothing. Where aprons have two overlapping front panels the total of the two panels when worn correctly must not be less than 0.3 mm in lead equivalence at 100 kVp.

Operators and other staff should use thyroid shields in all cardiology and interventional radiology suites. Relevant staff should be provided with protective gloves for use during all radiological procedures in which the hands and forearms may be in the primary beam.

All personal protective clothing should be clearly labelled with its lead equivalence and a unique identification number as specified by AS/NZS 4543.3.2000 and examined under fluoroscopy at least annually to confirm its shielding integrity. If damage to an apron is seen or suspected, it must be reported to the RSO immediately and the apron removed from service until its shielding integrity can be checked.

3.3. Protection of Relatives and Carers

- Any relatives of the volunteer or patient should be discouraged from entering the room during an examination unless they are required to assist with the examination. If they insist they must be asked to stand at least 2 m away from the patient and must wear a protective apron.
- Any person aiding an examination (e.g., restraining the volunteer or patient) shall use a protective apron and avoid facing the direct primary beam. If their hands are near the primary beam, they should be provided with protective gloves.

[2] Most protective aprons no longer contain lead, but are an alloy of high atomic number materials. References to aprons apply to all personal protective clothing.

- When children (as a volunteer) are to be examined, parent participation should be encouraged and adequate protection provided to the parents along with clear instructions as to the parent's role.

4. DENTISTRY

Besides all the above requirements for general radiology and any of the other requirements of RPS 10, the following excerpt from ARPANSA RPS No.10 is to especially be considered and included in all routines:

4.1. Clinical Assessment Of The Need For Radiography

The nature and extent of an actual or a suspected dental condition, its early detection, treatment and response to treatment must be the primary determining factors in submitting the patient to radiographic examination.

Radiology must not be used as a substitute for a clinical investigation, and therefore radiography must not be undertaken until a medical history has been taken and a clinical examination has established the need for a radiological examination, unless an emergency situation dictates otherwise.

Radiology is a most valuable aid to oral diagnosis, but it must be employed in accordance with the dental and general health needs of the individual patient.

5. RESEARCH PROJECTS INVOLVING THE IRRADIATION OF HUMANS

Where a project is to be undertaken for research purposes on humans the research must conform to generally accepted ethical and scientific principles.

To be medically justified, the information gained must be used to affect the care of people discovered to have a particular condition. For each project, there must be full compliance with the NHMRC's *National Statement on Ethical Conduct in Research Involving Humans* (1999) and the requirements of ARPANSA's *Code of Practice for Exposure of Humans to Ionizing Radiation for Research Purposes,* Radiation Protection Series Publication No. 8 (2005). The University of Newcastle HREC and HNEAH HREC monitor and manage this compliance as part of their approval processes for University of Newcastle activities which involves irradiation of humans.

Such projects must be so designed that the frequency of radiographic examinations and the number of images per examination is the minimum necessary and every effort must be made to provide the individual patient with some direct benefit from the examinations made. Recommended dose constraints apply in cases where there is no direct benefit to volunteers.

6. VETERINARY

6.1. Diagnostic radiology must only be undertaken if:

(a) there is a clear indication for the procedure; and
(b) it can be done without undue radiation hazard.

6.2. Only people who are essential to a procedure are permitted to be present during radiological examinations.

6.3. Each person present during a radiological examination must be:

6.4. properly instructed to enable them to understand their part in the proposed procedure; and

6.5. where practicable, positioned behind a protective screen.

6.6. Each person who is unable to position themselves behind a protective screen must:

(a) wear a protective apron; and
(b) remain as far as practicable from:
(i) the primary X-ray beam,
(ii) the animal, and
(iii) the X-ray tube assembly.

6.7. Adequate facilities and devices must be available to ensure:

(a) physical control over the animal; and
(b) protection of the operator.

6.8. Radiography must only be carried out using an appropriate X-ray machine that satisfies the relevant requirements of Schedule B, ARPANSA RPS 17.

6.9. Radiography may be considered in two categories:

(a) radiography within a defined X-ray room or area (A defined X-ray room or area must have sufficient shielding to ensure that no person can receive a radiation dose in excess of the relevant radiation protection limits specified in RPS1.); or
(b) radiography outside a defined X-ray room or area when a mobile or portable X-ray machine is taken to the animal (An X-ray examination must not be carried out outside a defined X-ray room or area unless it is not practicable to bring the animal to that room or area.).

6.10. For further information and controls please refer to ARPANSA RPS 17 Schedule B.

6.11. The handling and exposure of the animals must comply with the Animal Research Act 1985 and also the Australian code of practice for the care and use of animals for scientific purposes. . The University of Newcastle ACEC monitors and manages this compliance as part of their approval process for University of Newcastle activities involving veterinary radiology.

DOCUMENTATION

None

AUDIT

The integrity of protective aprons to be audited at least on an annual basis.
Staff radiation exposures to be reviewed quarterly.

REFERENCES

PD2017_032 Clinical Procedure Safety

Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation, ARPANSA 2019

Radiation Protection in Veterinary Medicine. RPS No. 17. ARPANSA. July 2009

EPA Policy on x-ray protective clothing

Animal Research Act 1985 No 123

Animal Research Regulation 2010.

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Dec., 2013	draft	William Bartolo, Bartolo Safety Management Service
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INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Optimisation of Exposures in Radiology
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S8
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, x-rays, radiology, medical imaging
SUMMARY *Brief summary of the contents of the document*	Procedures to optimise volunteer or Patient exposure to radiation from diagnostic x-ray procedures involved in research.

INDEX – Section 8

1. BACKGROUND

Within the NSW Radiation Control Regulation 2003 there is provision to protect personnel, volunteers and patients from unnecessary doses of radiation during research using diagnostic radiology procedures. The minimal doses of radiation required for diagnostic purposes may not be exactly known and hence procedures are required that allow such research to occur, while at the same time offering protection of the volunteer from undue radiation.

In general the minimal radiation required is a balance between volunteer or patient dose and image quality. If the image is compromised by reducing the dose to protect the volunteer or patient, then this may ultimately lead to repeat examinations and therefore higher volunteer or patient doses. The dose required will be determined by the image quality required for the research project and the size and shape of the volunteer or patient.

Typical uses of diagnostic radiology are bone X-ray, fluoroscopy, and CT procedures. Adaptation of normal protocols is a necessary part of diagnostic radiology to minimise radiation and to take into account different anatomical shapes, sizes and ages, as well as volunteers or patients who are pregnant.

2. RESPONSIBILITIES

2.1. The Chief Investigator

Prior to research involving radiation procedures commencing, the chief investigator must obtain approval from:

- The University Human Research Ethics Committee (HREC), AND
- The University Chemical and Radiation Technical Committee (CRTC) (Safety Approval)

Note:

- under circumstances where the owner and responsibility of the radiation equipment being used for the research is not the University, but an outside organisation, institute or commercial facility, the chief investigator must submit the approvals from that organisation’s or institute’s equivalent committees as part of their safety review application.

The Radiation Medical Practitioner (The Radiologist)

The Radiologist is responsible for the clinical management of the volunteer or patient undergoing the approved diagnostic procedure. This includes providing advice to the volunteer or patient about the procedure that is to be performed and ensuring that the imaging protocol to be followed has been optimised so as to minimise the radiation exposure to the volunteer or patient.

2.2. The Radiographer

The radiographer is responsible for performing the radiology procedures as prescribed by the radiologist in accordance with the approved protocol, including any protocol modifications specified for a particular patient.

2.3. The Radiation Safety Officer

The RSO will monitor and provide advice on radiation safety for the approved project.

PROCEDURE

Procedures for the correct identification of the volunteer or patient, procedure and sites

All clinical research staff shall comply with the NSW Health Policy Directive PD 2017_032 Clinical Procedure Safety.

A Poster or trolley slip must be displayed in the vicinity of volunteer or patient interviews where correct identification is being determined

Note: There are further resources available to support the above Health Policy Directive at the following link – Clinical Excellence Commission – Clinical Procedure Safety. Typically the procedure ensures that the volunteer or patient (if necessary via a parent or guardian) has been:

- provided with enough information about the procedure and its hazards to make an informed consent;
- asked to state their name, date of birth and address;
- asked to state the nature of the procedure that they believe is about to be undertaken
- asked about their pregnancy status if female and of childbearing age

In addition, immediately prior to the start of the procedure, the radiographer or radiologist should confirm that identity check of the volunteer or patient matches that on their paperwork indicating the patient, procedure and site for the study requested.

4. PROCEDURES FOR EXPOSURE OPTIMISATION

4.1. Radiography

The radiographer will:

- tailor the kVp, beam filtration and mAs to the volunteer's specific anatomy;
- restrict the number of exposures per examination to the minimum necessary;

- choose the most efficient image receptor required to achieve the diagnostic information (e.g., fast versus slow intensifying screen speed, correct matching of film and screens);
- avoid the universal use of anti-scatter grids, most particularly in the context of radiography and fluoroscopy of volunteer's under the age of 18 years;
- collimate the primary X-ray beam to within the size of the image receptor in use and only expose the clinically relevant region of interest. This has the added benefit of simultaneously improving image quality and lowering dose;
- avoid the use of extremely short source to clinical target distances as this can lead to unnecessarily high skin doses;
- shield radiosensitive organs such as the gonads, lens of the eye, breast and thyroid whenever feasible, unless they are the clinical target. Note that where the use of shielding will obscure the desired information relevant to the examination (e.g. ovarian shields in an abdominal X-ray) the use of such shielding is discouraged. (Note: protective drapes do not guard against radiation scattered internally within the body and only provide significant protection in cases where part of the primary X-ray beam is directed towards structures outside the immediate area of interest); and
- exercise extra care when using digital radiography systems with wide dynamic ranges, such as Computed Radiography (CR) and flat panel detectors. Choosing the appropriate image processing parameters is just one aspect of the procedure that the operator needs to consider. Volunteer dose may be increased to excessive levels without compromising image quality in the phenomena known as 'exposure creep' and it is therefore recommended that Automatic Exposure Control (AEC) devices be utilised with digital imaging systems.

Additional information can be obtained from the European guidelines which have been developed to provide specific advice on good technique from the IAEA Radiation Protection of Patients website.

4.2. Fluoroscopy

The radiographer will:

- use automatic brightness control (ABC), low frame rate, pulsed fluoroscopy, and last image hold (LIH) routinely when they are available;
- optimise the radiographic geometry (i.e. avoid geometric magnification) as poor technique combined with poor geometry can cause patient skin doses to be unnecessarily elevated such that deterministic effects may occur. The X-ray tube should be kept at maximum distance from the patient and the imaging receptor as close to the patient as possible;
- use the largest image intensifier or flat panel field size collimated down to the region of interest that is consistent with the imaging needs. That is, avoid electronic magnification (i.e. use of small field sizes). Electronic magnification results in dose

rates to the patient that may be several times higher than those that apply when the largest field size is chosen;

- choose the lowest dose rate options available commensurate with image quality requirements. This may mean keeping tube current as low as possible by keeping the tube voltage as high as possible or using pulsed fluoroscopy if it is available;
- avoid the universal use of anti-scatter grids. Remove the grid when examining small patients or when the imaging device cannot be placed close to the patient;
- minimise the fluoroscopy time. However, operators should be aware that elapsed fluoroscopy time is not a reliable indicator of dose. Volunteer size and procedural aspects such as locations of the beam, beam angle, image receptor dose rate, and the number of acquisitions can cause the maximum skin dose to vary by a factor of at least ten for a specific total fluoroscopy time;
- choose the lowest frame rate and shortest run time consistent with diagnostic requirements during digital image acquisition procedures (e.g. digital subtraction angiography (DSA) and cardiac angiography);
- consider employing additional strategies including the use of additional or k-edge beam filtration, and radiation-free collimator adjustment whenever possible;
- consider options for positioning the volunteer or altering the X-ray field or other means to alter the beam angulation when the procedure is unexpectedly long so that the same area of skin is not continuously in the direct X-ray field (skin sparing); and
- be aware that dose rates will be greater and dose will accumulate faster in larger volunteers. However, in complex procedures, operator choices and clinical complexity are more likely to affect volunteer dose than the physical size of the volunteer.

4.3. CT Procedures

CT procedures are increasingly common and give rise to some of the highest radiation doses in diagnostic medical imaging. Accordingly, all common CT procedures should follow established protocols which have been optimised for volunteer dose and image quality. The operator of a CT scanner should tailor the technical factors of the examination (kVp, mAs, nominal collimated X-ray beam width, pitch, volume of volunteer scanned) to the:

- individual volunteer anatomy; and
- diagnostic information being sought

Whenever possible, automatic exposure control (AEC) which varies the current according to the attenuation through the volunteer should be employed. Dose reductions of 30% to 60% have been reported using AEC compared to protocols which use fixed mA.

4.4. Pregnancy and Protection of the Embryo/Foetus

The radiologist or radiographer will:

- enquire about the possibility of pregnancy in all female volunteers or patients of childbearing age.
- indicate to the volunteer or patient why there is a need to know, to avoid them taking offence and refusing to answer or answering less than truthfully
- use an interpreter if there is any possibility that a language barrier would prevent the volunteer or patient from understanding the question
- not proceed with diagnostic radiology in the abdominal region if there is any doubt about the status of pregnancy Note: General radiographic examinations of the extremities, head and skull, mammography and CT examinations of the neck and head can be undertaken on pregnant or possibly pregnant women without concern as the scattered dose to the foetus is minimal.
- Ensure signs are displayed in prominent places throughout each facility where X-rays are used advising volunteers to notify staff if they may be pregnant. These signs will be written in several languages relevant to the community. An example might read as follows:

IF IT IS POSSIBLE THAT YOU MIGHT BE PREGNANT, NOTIFY THE RESEARCHER BEFORE YOUR X-RAY EXAMINATION.

However, the posting of signs in no way absolves the researcher, radiographer or the radiologist/physician/surgeon of their responsibility to enquire about the possibility of pregnancy in all female volunteers of childbearing age. When asking the volunteer about the possibility of pregnancy it is also important to indicate to the volunteer why there is a need to know, to avoid them taking offence and refusing to answer or answering less than truthfully. When language barriers exist, it may be useful to seek the service of an appropriate interpreter.

When doubt exists about the pregnancy status of an individual woman and moderate or high doses to the lower abdomen are involved, the Researcher/Radiologist should consider serum β-HCG testing before starting the procedure.

General radiographic examinations of the extremities, head and skull, mammography and CT examinations of the neck and head can be undertaken on pregnant or possibly pregnant women without concern as the scattered dose to the foetus is minimal.

4.5. Procedure when the volunteer is known to be pregnant

The radiographer will:

- Consult with the researcher and radiologist to determine if the procedure is still required

- Consult with the researcher and radiologist to determine the appropriate radiation exposure settings and procedures to minimise exposure of the foetus
- Keep written records of such consultations

Note the written record of consultation will include:

(i) the volunteer's height and weight

(ii) the particular x-ray apparatus used

(iii) the part of the body irradiated and projection (e.g., AP, LAT)

(iv) the entrance field size

(v) the focus to surface distance (FSD)

(vi) the x-ray filtration in mm of Aluminium

(vii) the kVp, mAs (or mA and time) and the number of exposures for radiographic studies

(viii) the kVp, mA, total screening time and, where available, the dose-area product (DAP) for fluoroscopic studies

(ix) the kVp, mA, slice thickness, rotation time, pitch, scan length and the DLP (dose length product) for CT studies.

4.6. When a volunteer is found to be pregnant AFTER a radiological procedure

A Medical Physicist will:

- estimate the radiation dose to the foetus/conceptus
- Advise the obstetrician or medical practitioner caring for the patient or volunteer of the calculated dose and provide additional information if available to allow evaluation of any possible risk to the foetus/conceptus.

4.7. Patient Radiation Doses for Common Procedures

The tabulated numbers in Appendix 8.1 are guides only as the actual dose that an individual receives may vary substantially depending on the:

- patient's anatomy;
- equipment used; and
- exact type of examination undertaken.

DOCUMENTATION

Nil

AUDIT

Survey of doses against the Diagnostic Reference Levels

REFERENCES

PD2017_032 Clinical Procedure Safety

The Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology (RPS 14.1), ARPANSA 2008

8. REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Dec., 2013	draft	William Bartolo, Bartolo Safety Management Service
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Sept., 2021	Revision 9	Ms M Musicka & William Bartolo

Attachment 8.1

Approximate effective doses arising from common radiological examinations in adults

Effective Dose Range (mSv)	Radiological Examinations
0 – 0.1	Extremities Skull Cervical spine Chest Bone densitometry
0.1 – 1.0	Thoracic spine Lumbar spine Abdomen Pelvis Pelvimetry Mammography (2 view)
1.0 – 5.0	Intravenous pyleogram (IVP) Barium swallow Barium meal CT head CT cervical spine CT chest (without portal liver phase)
5.0 – 10.0	Barium enema Angiography – coronary Angiography – pulmonary Angioplasty –coronary (PTCA) CT chest (with portal liver phase) CT renal (KUB) CT abdomen/pelvis – single- phase CT thoracic spine CT lumbar spine
>10	Angiography – abdominal Aortography – abdominal Transjugular intrahepatic porto-systemic shunt (TIPS) RF cardiac ablation CT chest/abdomen/pelvis CT abdomen/pelvis – multi-phase studies

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Safety in Nuclear Medicine including Veterinary
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S9
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EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, Nuclear Medicine, gamma rays, radionuclide, radioactive, PPE
SUMMARY *Brief summary of the contents of the document*	Procedures to limit the risk to health of staff and members of the public arising from exposure to radiation from Nuclear Medicine at any facility at the University of Newcastle.

INDEX – Section 9

1. BACKGROUND

Nuclear medicine uses small amounts of radioactive materials (radiopharmaceuticals) to diagnose and treat disease.

In diagnostic Nuclear Medicine, radiopharmaceuticals may be injected, inhaled or swallowed. Radiation emitted from the patient is then detected in order to provide structural and functional information.

In therapeutic Nuclear Medicine, radiopharmaceuticals may be administered orally, intravenously, or into a body cavity in order to treat disease, or to provide palliative pain relief.

Nature of the hazard

Radionuclides commonly used for diagnostic studies in Nuclear Medicine are mostly gamma emitters with short half lives (from hours to several days). A few beta emitting radionuclides are used for therapy, both systemic (administered orally or by injection) and intracavity (injection). Therapeutic radionuclides usually have longer half-lives ranging from days to months. With all unsealed sources, there is a potential for both external and internal exposure. Sealed sources of long lived radionuclides, primarily ^{57}Co, ^{133}Ba, ^{137}Cs and ^{153}Gd are used for testing instrumentation. These are primarily an external exposure risk.

External Exposure

Exposure to staff occurs mainly from radiopharmaceutical preparation, dose administration and directly from subjects to whom a radiopharmaceutical has been administered. Exposure from most sources can be reduced by shielding. The principal source of external exposure to personnel is the subject. While providing nursing care or positioning the subject for imaging, reducing exposure depends mainly on working as quickly as possible.

Internal Exposure

Internal exposure of personnel is very unlikely in routine practice. However it can occur as a result of contact with a spill of radioactivity arising from, for example:

- a leak during administration of a radiopharmaceutical
- body fluids from the patient, especially urine, saliva or vomitus
- a dropped or damaged source container

Airborne activity may be released when a vial containing an ^{131}I capsule is opened, or when ^{99m}Tc as Technegas is used for lung ventilation studies. Studies have shown that, in normal practice, inhaled ^{99m}Tc usually contributes less than a few percent of annual radiation exposure.

2. HUMAN CLINICAL

2.1. Area Designation in Nuclear Medicine

In *Controlled Areas*, University Personnel are required to follow specific procedures aimed at controlling exposure to radiation. There is usually restricted access marked by appropriate signage, and no eating or drinking is permitted in these areas.

Generally in the Nuclear Medicine, the Hotlab / Radiopharmacy, Therapy rooms and injection and scanning areas will be designated as controlled areas.

Corridors adjoining rooms where activity is present are also usually designated controlled areas and should not provide public thoroughfare to other areas of the facility.

In *Supervised areas* working conditions are kept under review but special procedures to control exposure to radiation are not normally necessary.

Generally in the Nuclear Medicine facility, the waiting areas and patient toilet are designated as supervised areas.

Nuclear Medicine facilities must be registered under the RML as a “Premises on which radioactive substances are kept or used”, and are generally classified as “Medium Level” premises under the classification system.

2.2. RESPONSIBILITIES

The Radiation Medical Practitioner (The Nuclear Medicine Specialist)

The Nuclear Medicine Specialist is responsible for the clinical management of the subject undergoing a diagnostic or therapeutic nuclear medicine procedure. This includes the decision to proceed with a Nuclear Medicine procedure based on the specialist’s knowledge of the potential risks and benefits of the procedure, taking into account the clinical information, and the sensitivity and specificity of the procedure

2.2.1. The Referrer

The referrer of the subject for a diagnostic or therapeutic procedure needs to be satisfied that the procedure is justified being aware that the subject will receive a radiation exposure. The referral[1] must state the clinical question that the diagnostic procedure should try to answer, or in the case of a therapeutic procedure, the medical condition for treatment. The referral should also alert the radiation medical practitioner when the referrer is aware that a female subject is pregnant or is lactating.

[1] The referral may be in hard copy or electronic form.

2.2.2. The administering person

Before any procedure is undertaken, the administering person needs to comply with the centre's operating procedures on how to identify the patient (See NSW PD2017_032 Clinical Procedure Safety)

The administering person needs to:

- be trained in intravenous injection and cannulation.
- use protective equipment designed to reduce radiation exposure (e.g. syringe shields, lead pots) and wear an approved personal radiation monitoring device when handling radioactive materials.
- ensure that only persons necessary to the procedure are present when performing administrations; and
- report any instance of accidental, abnormal or unplanned exposure to the HSW/RSO, and where required also in accordance RMP Section 19 – Radiation Incidents

2.2.3. The Nuclear Medicine Technologist

The nuclear medicine technologist is responsible for performing nuclear medicine procedures as prescribed by the nuclear medicine specialist in accordance with the University's written standard protocols.

This will include one or more of the following duties:

- perform imaging and in vitro protocols to ensure optimal data acquisition and analysis;
- prepare, dispense and administer radiopharmaceuticals;
- perform quality assurance procedures for radiopharmaceuticals, instrumentation and image quality.

The nuclear medicine technologist's role may include the responsibilities of the administering person and the person preparing radiopharmaceuticals.

2.2.4. The person responsible for radiopharmaceuticals

The person responsible for radiopharmaceuticals needs to develop systems for the:

- procurement of radionuclides/radiopharmaceuticals;
- storage and waste management of radionuclides/radiopharmaceuticals;
- in-house reconstitution of radiopharmaceuticals
- development of safe procedures and practices for the preparation and manipulation of radiopharmaceuticals, in consultation with relevant staff and the CRTC;

- implementation of a quality assurance program for radiopharmaceuticals.

The radiopharmacist/radiochemist, plays, in addition to the above duties, a central role in the:

- in-house manufacture of radiopharmaceuticals;
- implementation of a comprehensive quality assurance program for radiopharmaceuticals; and
- provision of advice on the safe and efficacious use of radiopharmaceuticals.

2.2.5. The Nuclear Medicine Physicist

A Nuclear Medicine Physicist is required to be available for consultation on optimisation of medical exposures, including clinical dosimetry and quality assurance, and to give advice on matters relating to radiation protection.

The nuclear medicine physicist works closely with the nuclear medicine specialist and technologists in the optimisation of clinical studies – through image acquisition, analysis and display optimisation and ongoing oversight of the quality control of equipment.

In addition, a medical physicist is required to provide Human Research Ethics Committees with a radiation dose estimation and risk assessment for any research studies that involve the research participants receiving an exposure from ionizing radiation, in accordance with the requirements of ARPANSA's Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes (2005).

2.2.6. The Radiation Safety Officer/CRTC

The RSO/HSW will oversee and provide advice on radiation safety within the areas of Nuclear Medicine.

PROCEDURE

2.3. General Procedural Considerations

- Gloves must be worn whenever handling unsealed radioactive sources.
- Eating and drinking in Controlled Areas is strictly prohibited and neither food nor drink may be stored in a refrigerator used for storing radioactive materials.
- Any cut or break in the skin should be covered with a waterproof dressing before a person enters an area where unsealed radioactive materials are handled.
- Radioactive materials should be received, handled, and stored at the specifically designated controlled location. Vessels containing radioactive materials should be labelled with the radionuclide name, chemical form,

activity, and date and time of calibration, and should be properly shielded while in use and in storage.

- All containers used for radioactive materials to be clearly labelled with the radionuclide, form, activity, time, date and when appropriate, a note as to the sterility/ expiry time or otherwise.
- All such containers are to be adequately sealed and shielded at all times. Except for very small activities, containers are not to be handled directly and if possible, long handled tongs or syringe shields should be used.
- Equipment provided specifically for the safe handling of unsealed radioactive materials should always be used and should not be removed from the work area. Pipettes should never be operated by mouth. Recapping of syringe needles, if absolutely necessary, should be performed using a suitable recapping device.
- Shielding should always be considered for any radioactive source. The prior risk assessment should identify the shielding that is required and what type and form it should take. Appropriate shielding may be obtained using a variety of materials such as tungsten, lead, lead glass, aluminium or Perspex, depending on the characteristics of the radionuclide to be shielded.
- Lead syringe holders should be used to transport syringes containing radioactive materials. Syringe shields should be provided for ready use during radiopharmaceutical preparation and administration whenever practicable. It should be noted that any additional time spent in manipulating the syringe when adjusting the activity to be administered to a patient can result in additional dose to the hands of the administering person.
- All work surfaces where unsealed radioactive substances will be used must be covered with absorbent paper such as “Benchcote”.
- All staff handling radioactivity are to be familiar with contamination and decontamination procedures.
- Personal radiation monitors are to be worn by designated staff at all times when working in the DRA. Designated staff include all nuclear medicine technologists, physicians, physicists, radiochemists, nursing staff and other relevant university personnel.
- Finger radiation monitors are to be worn on the index finger of the injecting hand by technologists, when any radioactivity or radioactive subjects are being handled.
- Packaging, containers, lead pots etc. which no longer contain radioactive material and which are to be disposed of MUST have any radiation warning labels removed or covered before disposal. Empty containers, lead pots and packaging MUST be removed from the working area and disposed as appropriate.
- A long-sleeved gown must be worn when administering Technegas to a subject.

- During imaging in the scanning rooms, the staff should remain behind the lead glass shielded console areas as much as possible.

For procedures specifically relating to Preparation and Dispensing of Radiopharmaceuticals, see section 4.5 below.

2.4. Facilities required

The radiopharmacy facility should be located, designed, constructed and maintained to suit the operations to be carried out. The layout and design should be such as to minimise the risk of errors and to permit effective cleaning and maintenance, the avoidance of cross contamination, the build-up of dust or dirt and any other influences that may adversely affect the quality of radiopharmaceuticals. Additionally, the facility needs to be designed to give proper radiation and contamination protection to personnel.

Construction features of a laboratory area should include:

- **Floors**: smooth, continuous, non-absorbent, washable, no penetrations. eg. Welded sheet vinyl coved up the walls
- **Walls**: Shielded, free of dust collecting ledges and pipework. eg. concrete, masonry, plasterboard with lead lining, high gloss paint, sheet vinyl, laminate
- **Bench Tops**: Resistant to chemicals, hard wearing, strong supports, lipped & coved. eg. High grade laminate on water resistant board, polymer resins, stainless steel.
- **Plumbing**: Draining direct to main sewer traps for monitoring, eg. Shower, toilets for patient, shower, toilets, handbasin, eyewash for staff; sink, cleaners sluice, pan steriliser.
- **Air handling**: controlled temperature and humidity, exhaust ventilation for waste store, I-131.
- Usually, there should be a shielded store for waste.
- *(AS/NZ 2982. Laboratory Design and Construction)*

2.5. Equipment required

Radiopharmacies, laboratories and other work areas where unsealed radioactive substances are handled should be provided with radiation protection equipment kept specifically for this purpose. This equipment may include:

- lead barriers (fixed or mobile) with lead glass windows for work with photon emitters;
- Perspex barriers for work with beta emitters;
- syringe shields;
- shielded containers;
- drip trays to contain any spillage;
- tongs or forceps to maximise the distance of the worker from the source;

- radiation and contamination monitoring equipment;
- dose calibrators;
- fume cupboards;
- biohazard cabinets;
- shielded transport containers; and
- equipment and materials to deal with spills.

2.6. Personal Protective Equipment.

Protective clothing is to be used in work areas where there is a likelihood of contamination, both to protect the body or clothing of the worker and to help prevent contamination to other areas. The clothing should be monitored and removed before leaving designated areas, e.g. when visiting the staff room.

The clothing may include:

- laboratory coats or protective gowns;
- waterproof gloves; and
- face masks where there is a risk of airborne droplets.

Overshoes are not routinely required but may be needed in radiopharmacies handling greater than 200 GBq of technetium-99m and should be included in the decontamination kit, to be worn when cleaning up a major spill.

The following uses of personal protective equipment are suggested:

Gloves	Unpacking radionuclide packages Administering diagnostic injections Handling closed waste containers Administering I-131 capsules Preparing low activity samples for counting
Gloves, gown	Milking Mo-99 generator Preparing radiopharmaceuticals Dispensing injections Nursing sweaty or incontinent subjects Changing contaminated bedding Administering lung ventilation radiopharmaceuticals Preparing Tc-99m sources for gamma camera QC
Gloves, gown, plastic apron	Emptying bed pans, bottles, catheter bags, changing contaminated bedding
Gloves, gown, eye protection	Giving therapy injections or oral liquids, eg Sr-89, Y-90, I-131, (I-131 MIBG, or I-131 iodide) Labelling blood cells
Double gloves gown overshoes	Cleaning up spills

In certain circumstances staff may need to wear a protective lead apron. This may be necessary if staff need to be in close contact with subjects containing greater than 800 MBq of ^{99m}Tc, such as during myocardial perfusion studies or gated cardiac blood pool studies. Protective aprons should preferably have a thickness of 0.5 mm lead equivalence. Preferred designs are those comprising a separate vest and skirt that wrap around fully, as open back designs are not recommended. All protective clothing should be examined under fluoroscopy at least annually to confirm the integrity of the protection.

Lead aprons provide little or no protection for higher energy photons and should not be used for radionuclides such as gallium-67 or iodine-131 or for positron emitters.

Staff leaving designated areas should remove protective clothing, wash their hands and monitor their hands, clothing and body as appropriate.

Mobile shielding barriers may be required for therapeutic nuclear medicine procedures using gamma-emitting radionuclides.

Procedures for the preparation and dispensing of radiopharmaceuticals

The following rules should be observed when preparing or dispensing radiopharmaceuticals:

- eating, drinking, smoking, or the application of cosmetics are prohibited
- All preparation and dispensing of radiopharmaceuticals must be carried out behind suitable lead or lead-glass shielding
- disposable gloves should be worn at all times and preferably laboratory coats or gowns. Safety glasses must be used if the work is of a hazardous nature to the eyes. Gloves should be changed at regular intervals in order to minimise the spread of contamination;
- personal dosimeters are to be worn at all times when handling radioactive materials or working in areas where they are handled or stored;
- Packaging and containers for radioactive material must be observed for contamination on opening.
- The receipt of all radioactive material must be recorded in the local Radionuclide Register and also entered onto the central register..
- The work area should be prepared and set up by covering surfaces with plastic-backed absorbent material (such as Benchcote) and laying out needles, syringes, shields, forceps, diluents, gloves and other necessary items.
- radioactive materials should be kept in closed, sealed vials within shielding containers;

- For reconstituted vials, a radiopharmaceutical record sheet should be maintained that includes the batch numbers, manufacturer, date received, expiration time/date, the name of the person preparing the radiopharmaceutical, and any quality assurance tests performed. Identifying labels with a dated batch number should be affixed to radiopharmaceutical vials and shielding containers prior to the preparation of patient doses. These should identify the radiopharmaceutical, the total radioactivity, the volume and the time and date of calibration;
- Each individual patient/subject dose which is prepared must be recorded in the register and the staff member preparing the dose must be recorded electronically or by signature.
- all working surfaces should be covered with absorbent paper that has an impermeable plastic coating – plastic side facing the bench-top;
- small spills that present no radiological hazard to persons should be cleaned up as soon as possible. Major spills may require evacuation of the area before cleanup is undertaken and need to be reported immediately to the HS/RSO through the on-line incident reporting system (AIMS). See RMP Section 19.
- Mouth pipetting of any radioactive substance is TOTALLY PROHIBITED
- interruptions to the preparation or dispensing of radiopharmaceuticals should be avoided;
- in order to demonstrate confinement of radioactivity, a suitable electronic radiation detector should always be available when radioactive materials are handled;
- hands, shoes and clothing should be monitored for contamination in a low-background area, allowing sufficient time for instrument response, before leaving the radiopharmaceutical laboratory.
- A radiation survey for contamination and sources must be done at the end of the working day in the radiopharmacy dispensing bay and Hot Lab, paying particular attention to the waste bins. A complete radiation contamination survey MUST be done weekly with all results documented.

Special procedures for therapy administration

If there is ever any need to for this then reference and compliance with ARPANSA RPS 14 and sub sections is mandatory. HSW and the RSO must be consulted at all times for this.

2.7. Pregnant or Breastfeeding staff.

If an occupationally exposed member of the nuclear medicine staff is pregnant then the foetus should be afforded the same level of protection as a member of the public. This may be achieved by controlling the exposure of the employee such that the dose received by the foetus is less than the public effective dose

limit of 1 mSv for the remainder of the pregnancy. For external irradiation from technetium-99m or iodine-131, a dose of 1.3 mSv to the surface of the maternal abdomen has been shown to give rise to a dose of 1 mSv to the foetus. For higher energy photons, such as those from positron emitters, the dose to the foetus may be similar to the dose at the surface of the abdomen.

The likely dose to the foetus of a pregnant worker from each work activity should be assessed. This will usually require an examination of the worker's personal monitoring records and an assessment of the likelihood of incidents leading to either external or internal exposure of the foetus. If the foetus could receive more than 1 mSv over the declared term of the pregnancy a change in work practice should be discussed and agreed to with the worker. It would be prudent to provide an occupationally exposed pregnant worker with an electronic personal dose monitor.

Pregnant women, or those intending a pregnancy or breast-feeding, should not work with large amounts of radioiodine.

If a worker is breast-feeding she should not take part in procedures or work in areas where there is a significant risk of bodily contamination, e.g. cleaning up a large spill of radioactivity. An assessment should be undertaken of the potential radiation dose to the infant resulting from a chance inhalation by the mother of radioactive gases or aerosols arising from her work and appropriate procedures put in place to restrict this dose if necessary.

2.8. Emergency procedures in Nuclear Medicine

2.8.1. Accident Decontamination Procedures

There are three major causes of contamination by a radioactive material:

- Spillage from a source container
- Leakage during an injection procedure
- From patient excretion such as urine, faeces, sweat, saliva and vomitus.

Spills of radioactive material should not be regarded as an unavoidable hazard in the day-to-day operation of the department. Any spill carries some degree of risk and acceptance of minor spills may lead to a casual approach to major spills. Accidents involving radioactive material must be reported to the CRTC and the Radiation Safety Officer. In cases where personal injury is also involved, even if this is minor, e.g. a scratch on the skin where radioactive material may enter the person's body, an Incident Report Form (AIMS) must also be filled out.

The following procedure should be followed on discovery of a contamination problem:

i). All persons involved in the incident are to vacate the immediate vicinity but are not to move freely around the department, as this involves a danger of spreading contamination.

ii). Notify IMMEDIATELY, the University Radiation Safety Officer (or the medical physicist) and the senior technologist for the area.

iii). If the contamination is due to a container spill of liquid and the hands are protected with gloves, right the container, and ensure that it is adequately shielded. If the problem is due to a leaky syringe or other container, place suspect item in a labelled plastic bag and remove it to the Waste Room.

iv). Seal off the area involved and in particular ensure that personnel do not walk on any possible contaminated floor area. Discard any clothing which is contaminated and place it in a labelled plastic bag and store in Waste Room. If there is any radioactive material on the skin, flush thoroughly with water.

3.8.2. Decontamination of Personnel

i). Wash with soap and water scrubbing lightly with a soft nail brush, avoiding spreading contamination to the eyes and mouth. If the hair is contaminated, it will be necessary for the individual to shower in order to remove this contamination.

ii). Monitor with an appropriate radiation monitor until the count rate is less than 1000 cps or the dose rate is less than 10 μSv/hr. with the detector at a point close to (but not touching) the contaminated region of skin.

iii). Eyes which are contaminated should be washed using the dedicated eyewash station. The mouth should be rinsed with water.

iv). Contaminated wounds should be washed under fast running water and bleeding encouraged. Finally apply a gentle antiseptic and then a first aid dressing.

3.8.3. Decontamination of Work Environment or Equipment.

The following should be performed by the University RSO, the Chief Technologist or a Senior technologist:

i). Define the area of contamination using an appropriate survey meter and, if appropriate, mark hot spots with a felt tipped pen. Be aware that this pen may become contaminated and must be dealt with accordingly.

ii). Permit no person to resume work in the area until a survey is made and decontamination procedures have been satisfactorily carried out.

iii). Decontamination of any contaminated area cannot be performed by a fixed set of rules, but must have regard for the radioisotope form and type of contamination. The decontamination trolley stored in the Hot Lab should be used. The following general information applies in most cases:

- In cases of spillage during patient injection or drawing up of a dose, a suitably clad (gown, gloves, overshoes) person shall soak up any obvious liquid contamination with blue incontinence sheets or absorbent paper, placing them into a labelled plastic bag for storage. Once this step has been performed decontamination of contaminated surfaces can take place.
- Swabs or similar absorbent material soaked in decontamination fluid shall be used to swab and scrub small contaminated areas until a minimum decontamination effect is attained. This will in most cases mean that the surface dose rate at the area in question can be reduced to something less than 10 µSv per hour.
- Where items of equipment have been contaminated it may be preferable to store such items until the activity has been reduced to a safe level.

iv). Relatively low activity spills of ^{99m}Tc (count rate less than 1000 cps) may be handled by technologists in this manner. Areas that have been decontaminated and where the dose rate is still at a high level should be avoided until the activity has reached a safe level.

v). Floor surfaces that cannot be completely decontaminated, or where it is uncertain if further activity is present, should be covered with a plastic sheet until the activity has decreased to a satisfactory level. The covering must be marked with brief details such as radionuclide, dose rate and date.

Further advice on Decontamination principles and Decontamination Kits can be found in Radiation Incidents - (see RMP Section 19).

2.9. Miscellaneous Exposure from radioactive subjects.

On occasions when a subject who has already been administered a diagnostic radiopharmaceutical is then required to undergo another medical procedure a radioactive patient presents a source of radiation exposure to other workers. Therefore as a general rule, it may be prudent to consider performing other procedures before the administration of the radiopharmaceutical.

However, the risk to workers is extremely small, and in practice there are very few requirements for special scheduling of procedures for subjects who have been administered diagnostic radiopharmaceuticals. It is important to note that the prior administration of a radiopharmaceutical to a subject is not of itself a contraindication to performing X-ray, ultrasound or other procedures. A decision about what precautions should be adopted (if any) depends upon an assessment of the amount of radiation exposure to others from the subject as a result of the nuclear medicine procedure. The decision to proceed with the other test should be based primarily on clinical need. Social and economic factors should also be taken into account.

When balanced with

- medical implications of delayed diagnosis
- the cost for accommodation incurred by lengthening stays
- the inconvenience for subjects who must return for the test.

Special scheduling requirements would very rarely be justified.

With Sonography, due to the potential for extended periods of close contact, there is further advice in the form a policy directive issues by NSW Health available at: *Work Health and Safety - Limiting Staff Exposure to Ionising Radiation*

VETERINARY DIAGNOSTIC AND THERAPEUTIC NUCLEAR MEDICINE

2.10. PROCEDURES AND FACILITIES

Nuclear medicine involves the use of unsealed radioactive materials (i.e. liquid, aerosol or gaseous materials) for either diagnostic or therapeutic purposes. It introduces a further dimension of hazard in terms of ensuring adequate containment of the radioactive material during preparation, administration and in the subsequent care of the animal.

Diagnostic or therapeutic nuclear medicine veterinary procedures must only be performed:

(a) in an area that is specially designed for the purpose; and

(b) subject to a specific authorisation from the relevant regulatory authority.

Diagnostic veterinary nuclear medicine must only be undertaken by personnel who:

(a) are specifically trained in:
  i). radiation physics;
  ii). radiation biology; and
  iii). radiation hazards and protection,

(b) have practical experience in:
  i). nuclear medicine instrumentation;
  ii). imaging procedures;
  iii). quality control of the radiopharmaceuticals;
  iv). the handling of unsealed radioactive materials; and
  v). hot laboratory procedures & clinical practice, and

(c) are appropriately authorised by the relevant regulatory authority.

Therapeutic veterinary nuclear medicine must only be undertaken by personnel who:

(a) meet the requirements specified in the above clause for diagnostic nuclear medicine; and

(b) have additional training in:
(i) the biological pathways and distribution of radioactive materials;
(ii) radiation dosimetry;
(iii) experience in spillage mediation procedures; and
(iv) handling radioactive waste at levels encountered in therapy

Detailed written procedures must be developed for:

(a) decontamination; and

(b) the disposal of radioactive waste.

Dedicated facilities must be used for:

(a) storage, safe handling, manipulation and dispensing of unsealed radioactive sources;

(b) administration of unsealed radioactive materials to animals;

(c) subsequent housing of the animals;

(d) measurements of the radioactive materials in the animals and any subsequent investigations; or

(e) housing the animals before discharge once the studies are completed.

Appropriate radiation warning signs and instructions must be displayed on the kennel, box, stall or other enclosure in which the animal will be housed.

Written protocols for each type of nuclear medicine procedure must be developed before the procedures are implemented.

Suitable arrangements must be made for the discharge or disposal of animals.

A record of the receipt, use and disposal of all radioactive materials must be maintained.

2.11. SPECIFIC NUCLEAR MEDICINE PROCEDURES

Technetium-99m:

The following requirements must be implemented when using technetium-99m for nuclear medicine procedures:

(a) an isolated, shielded and secure accommodation must be used for:
i). administering the radioactive material; and
ii). hospitalising the animal after the administration[2].

(b) all personnel involved must be made aware that they are handling a radioactive animal;

[2] For the normal doses of technetium-99m used in bone imaging, the animal may be discharged the day after administration of the dose.

(c) the procedures and precautions must be:
  i). carefully planned; and
  ii). explained to all personnel involved with handling a radioactive animal;

(d) suitable animal restraints must be provided to minimise handling of the radioactive animal during imaging or other procedures;

(e) persons under the age of 18 years and pregnant women must not hold animals during nuclear medicine procedures and a notice advising of this requirement should be displayed prominently in the area;

(f) a separate shielded and secure location must be used for the imaging procedure;

(g) in order that they can be hosed down to remove any radioactive contamination, the walls and fixtures in rooms used for nuclear medicine procedures must be:
  i). waterproof and 'non-slip'; or
  ii). painted with waterproof paint,

(h) the floors must be sealed;

(i) the flooring material must:
  i). be readily cleanable;
  ii). cover the whole imaging area; and
  iii). be sealed or coved up at the edges,

(j) drainage must be provided to the normal establishment waste;

(k) procedures to minimise the contamination from urination must be considered[3];

(l) decontamination equipment must be available for easy and rapid decontamination of the area;

(m) bedding material must be absorbent;

(n) contaminated bedding and other material from the area must be disposed of after 24 hours,

(o) entry to the area must be prohibited between the time of injection and the time of removal of the animal for the imaging procedure;

(p) a syringe shield must be used for the injection of the radioactive technetium;

(q) provision must be made for appropriate shielding of the operator at the imaging console;

(r) the animal must be sedated as appropriate for the period of the imaging procedure; and

(s) radiography or other clinical investigations required must be delayed until the day after the administration of the technetium.

[3] Production of radioactive urine in the imaging area could not only be hazardous but it could also interfere with the imaging process. Minimisation of urination can be, for example, achieved by the prior use of an appropriate diuretic.

Treatment of feline hyperthyroidism with iodine-131:

Iodine is readily volatile and, if proper precautions are not taken, it is readily vaporised and can be inhaled and accumulate in the body. Also, vapours may build up in poorly ventilated areas thereby presenting a potential inhalation hazard to anybody in the vicinity.

The following requirements must be implemented for the treatment of feline hyperthyroidism with iodine-131:

(a) an isolated, shielded, well ventilated and secure area must be provided for:
   i). administering the radioactive material; and
   ii). (ii) hospitalising the cat for at least 5 days after the administration,

(b) the radioactive material must be kept in a shielded container until just before administration;

(c) if the radioiodine is injected either intravenously or subcutaneously:
   i). disposable gloves must be worn during the procedure; and
   ii). disposable gloves, the syringe barrel and any other item or material that might have become contaminated during the procedure must be stored as radioactive waste following the procedure[4],

(d) a well ventilated and shielded area must be available for storage of radioactive waste[5];

(e) all material removed from cages must be:
   i). handled with disposable gloves; and
   ii). stored as radioactive waste in accordance with detailed safety protocols;

(f) a written protocol for the handling of radioactive material must include details of:
   i). routine radiation monitoring of the area after administration; and
   ii). clean up procedures and radiation monitoring after a spillage[6];

(g) at the time of release, the treating veterinary surgeon must provide the owner of the cat with plain-language, written instructions for the handling of the cat for the following two weeks that include:
   i). instructions to avoid long periods (more than a few minutes) in close proximity to the cat, particularly during the first week;
   ii). information that it is safe to pick up the cat for short periods but that it should not sit on any person's lap for extended periods or sleep next to any person on a bed;
   iii). instructions that if the cat:
      1. urinates inside a dwelling, the urine should be cleaned up thoroughly with paper towels which are then placed in a rubbish bag; and

[4] Waste containing radioiodine should be stored for at least 6 weeks.

[5] The urine may contain up to half of the administered radioactivity in the first 3 days.

[6] Spillage of radioactive material could occur if the cat:
– bites and punctures a radioactive capsule; or
– regurgitates a capsule or its contents; or
– a syringe has its contents inadvertently expelled.

2. vomits inside a dwelling, the vomit should be cleaned up thoroughly with paper towels which are then placed in a rubbish bag;

iv). instructions that the cat should only be handled in well ventilated areas during this period ;

v). instructions to wear rubber gloves when cleaning up urine and to wash hands thoroughly afterwards; and

vi). instructions that if the urine has soaked into garments or carpets, they should be cleaned thoroughly,

(h) after administration:

i). the cat must, where practicable, be:

1. handled with disposable gloves; and
2. held at arm's length; and

ii). the treatment area and disposable gloves be monitored with an appropriate radiation survey meter,

(i) an extraction fan must be installed unless there is good natural ventilation;

(j) where the radioiodine is in capsule form:

i). the cat must be:

1. lightly tranquillised[7]; and
2. placed in a deep tray, such as a baby bath, lined with absorbent paper for administration of the radioactive material;

ii). where possible, long handled forceps must be used to insert the capsule well down the throat followed by about 20 ml of water introduced into the mouth by a syringe; and

iii). consideration must be given to the risk of subsequent vomiting by the animal,

(k) if a cat dies before treatment is completed, it must be:

i). sealed in a plastic bag;

ii). stored as radioactive waste until it can be cremated or released for burial; and

iii). cremated or released to the owner for burial after an appropriate decay time has been applied[8,9].

VETERINARY RADIOTHERAPY

2.12. Procedures And Facilities

The potential hazards are greater in radiotherapy than in the diagnostic use of radiation because of the larger exposures involved (often more than 1000 times those used in radiography) and also, in many cases, because of the use of more penetrating radiations.

[7] Tranquilisation is inappropriate in cats that may be cardiac or renally compromised with hyperthyroidism.

[8] The necessary period of time will be determined by the half life of the radionuclide used.

[9] Where a post mortem examination is required, the procedures observed during post mortem examinations are normally adequate.

The safe use of sealed radioactive sources that emit **gamma radiation** represents the possibility of greater hazard than the use of X-ray therapy machines. The use of such sources therefore requires considerable expertise and persons using them in radiotherapy need to have adequate training and extensive supervised experience in the handling of radioactive materials for therapeutic purposes.

Radiotherapy of animals must only be performed by, or under the direct supervision of, personnel:

(a) specifically trained and experienced in such procedures; and

(b) who are appropriately authorised by the relevant regulatory authority.

The therapeutic use of radiation must only be undertaken using special equipment and facilities designed for the purpose.

The facilities for the treatment and housing of the animal must be adequate for protection of:

(a) the persons caring for the animal; and

(b) any other person in the vicinity.

2.13. Sealed Radioactive Sources – Gamma-Ray Emitters

The storage and handling of the sources must be in accordance with the requirements of Section 9 below.

An up-to-date register must be maintained of all sealed radioactive sources that includes details of:

(a) where appropriate, the serial number or other identification of each sealed radioactive source;

(b) the physical or chemical form of the radioactive material;

(c) a photograph or diagram of the source;

(d) the date of receipt and its **activity** on that date; and

(e) the date and manner of ultimate disposal (including those sources permanently implanted in animals).

A radiation survey meter must be readily available that is:

(a) in good working order; and

(b) suitable for the type of radiation being used.

An appropriate personal monitoring device must be worn by each person handling radioactive materials.

At all times during the use of removable sealed radioactive sources in treatment:

(a) the animal must be housed:

i). under regular supervision;
ii). in strictly secure circumstances in an enclosure such as a kennel, box or stall, set aside for that purpose; and
iii). so that escape of the animal with sources in situ is most unlikely;

(b) the enclosure must be located:
i). in a position that is at least 3 metres from any normally occupied areas; and
ii). as far as practicable from frequently used corridors, passageways or other thoroughfares;

(c) the sealed radioactive sources to be used must be taken into the enclosure in their shielded container and then applied directly to the animal;

(d) upon removal of the sources from the animal and before the animal is released from the enclosure, the sealed radioactive sources must be:
i). checked;
ii). all accounted for;
iii). immediately returned into the shielded container; and
iv). returned to the store,

(e) if any damage to sources is observed following removal from the animal, the person responsible for the radioactive sources must be notified as soon as possible;

(f) no person is permitted to enter the enclosure apart from essential feeding and care of the animal;

(g) if a radioactive mould or applicator slips or becomes dislodged, the operator must notify the veterinary surgeon responsible for the treatment of the animal as soon as possible; and

(h) appropriate radiation warning signs and instructions must be displayed on the enclosure.

In the case of permanent implantation of radioactive sources into an animal, the animal must be housed and attended to unless or until the total activity in the animal is less than:

(a) for companion animals (i.e. domestic pets or animals normally in regular contact with humans), 1.2 GBq (~32 mCi) of gold-198; or

(b) for field animals (i.e. animals normally held in a paddock or very large yard and not in contact with humans), 6 GBq (~160 mCi) of gold-198.

For companion animals, the housing and care referred to above must be at the premises of the veterinary surgeon.

When the activity of the source is less than the values given above and the animal is released into the custody of an adult, that person must be provided with:

(a) a suitably shielded container; and

(b) appropriate written instructions that:

i). apart from essential feeding and care, persons not remain closer than one metre from the animal for 4 days after discharge of the animal;
ii). no animal be ridden, groomed or have any extensive contact with humans until at least 14 days after discharge;
iii). if any radioactive seed or grain from the implant becomes accidentally dislodged, it is only retrieved using tweezers, pliers or other long-handled implements, placed in the suitably shielded container referred to above and kept in safe custody until disposed of;
iv). details of how to dispose of a source should it become dislodged; and
v). on no account should any radioactive seed or grain be handled in the fingers or kept as a curio.

If an animal dies before treatment is completed, the person responsible for the radioactive material must:

(a) be notified as soon as possible; and

(b) arrange for removal of the sources.

2.14. Sealed Radioactive Sources – Beta Particle Emitters

The only radioactive element in common use as a sealed radioactive source of beta particles for radiotherapy is strontium-90. This is made up in a form suitable for surface application to thin accessible lesions. It is important to note that a strontium-90 applicator, although appearing quite innocuous, is a very delicate and potentially hazardous device. Manufacturers suggest that expected life of a strontium-90 applicator is 15 years although this may be able to be extended with careful handling.

2.14.1. Use of an applicator

A strontium-90 applicator must only be used by a person appropriately authorised by the relevant regulatory authority to do so.

The applicator must be fitted with an appropriate handling device for use.

The active face of the plate must not be viewed directly.

2.14.2. Damage, loss or disposal of an applicator

A plate that has been damaged in any way[10] must be returned immediately to an appropriate body for checking, possible repair and testing for radioactive leakage.

The loss of an applicator must be reported to the relevant regulatory authority immediately.

Strontium-90 applicators must only be disposed of subject to authorization by the relevant regulatory authority.

[10] For example, the boss broken off or the flat active section bent or scratched.

2.14.3. Storage of strontium-90 applicators

A strontium applicator must be stored in a container that is designed:

(a) with the smallest overall external dimension of the box not less than 0.1m;

(b) to protect the plate from damage;

(c) to provide adequate radiation shielding; and

(d) so that the plate cannot move or be dislodged during transport.

The plate must always be kept in its special container when:

(a) not in use; or

(b) being transported.

The outside of the box must carry the:

(a) appropriate radiation warning symbol;

(b) name of the radioisotope (strontium-90);

(c) nominal activity;

(d) date of measurement; and

(e) name, address and contact telephone number of the Responsible Person.

Storage Of Veterinary Sources Of Radiation

2.14.4. Storage Of Radioactive Sources Used In Veterinary Medicine

A sealed or unsealed radioactive source used in veterinary medicine should be securely stored if it:

(a) is not required for immediate use; or

(b) has been removed from use.

When a sealed and unsealed radioactive source used in veterinary medicine is placed in storage:

(a) the radioactive source should be stored so that the likelihood of damage to the source is minimised. Damage to a gauge in storage could result from a fall, collision, corrosion etc.;

(b) the source container should be clearly labelled as containing a radioactive source;

(c) the source container should be locked or otherwise secured; and

(d) the source container should be monitored to ensure that:
i). the source is actually inside the container; and

ii). the dose rate at the surface of the container will not result in any person exceeding the relevant dose limit specified in local legislation and in RPS-C1.

A store used for radioactive sources should:

(a) be of solid construction and made of durable materials;

(b) be designed, located, constructed and, if necessary, shielded so that:
i). the radiation levels at any accessible place outside the store do not result in an ambient dose equivalent rate or directional dose equivalent rate, as appropriate, exceeding 10 $\mu Sv.h^{-1}$;
ii). no person will receive a radiation dose in excess of the appropriate limit specified in local legislation and in RPS1;
iii). the resultant radiation dose rate in any occupied area is as low as reasonably achievable; and

(c) be under the control of a person nominated by the Responsible Person;

(d) be kept locked;

(e) be subject to strict access control;

(f) not be used for other purposes; and

(g) bear a conspicuous notice displaying the radiation hazard warning symbol, when a radioactive source is in the store. The letters and symbol of the notice should be in black on a yellow background. An example of a suitable notice is given below.

A store used for the storage of a sealed and unsealed radioactive source used in veterinary medicine should not be located:

(a) • near to explosives, combustible or corrosive materials or photographic or X-ray film;

(b) • in an area prone to flooding or other potential hazard that may damage the store and/or its contents; or

(c) • in an area that allows unrestricted access to the public.

3. EXAMPLE OF A WARNING NOTICE FOR A RADIOACTIVE MATERIAL STORE

4. DOCUMENTATION

None

5. AUDIT

Worker Radiation Exposure Records to be reviewed quarterly

REFERENCES

NSW PD2017_032 Clinical Procedure Safety

ARPANSA Code for Radiation Protection in Medical Exposure guideline RPS 14.2

AS/NZ 2982.1 Laboratory Design and Construction Part 1 General Requirements

ARPANSA Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes (2005) (RPS 8)

ARPANSA CODE OF PRACTICE & SAFETY GUIDE. Radiation Protection in Veterinary Medicine RPS 17 (July 2009)

Animal Research Act 1985 No 123

Animal Research Regulation 2010.

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INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

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AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
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SUMMARY *Brief summary of the contents of the document*	Procedures to optimise patient, foetal and carer radiation exposures from Nuclear Medicine procedures.

INDEX – Section 10

1. BACKGROUND

Once research and clinically is justified, each examination should be conducted so that the dose to the volunteer/patient is the lowest necessary to achieve the research or clinical aim. It is also crucial that the procedure is performed safely and exactly as prescribed.

Since volunteers/patients may accrue direct benefits from medical exposures, it is not appropriate to impose strict limits on the doses received from fully justified examinations. However, volunteer/patient dose surveys demonstrate significant variations in delivered dose to achieve satisfactory image quality indicating that there is scope for the implementation and optimisation of volunteer/patient protection. Once the radiopharmaceutical has been administered, there is also significant scope for optimising radiation dose for researchers, relatives and carers.

2. RESPONSIBILITIES

The Radiation Medical Researcher (The Nuclear Medicine Specialist)

The Nuclear Medicine Specialist is responsible for the clinical management of the volunteer/patient undergoing a diagnostic or therapeutic nuclear medicine procedure. This includes the decision to proceed with a Nuclear Medicine procedure based on the specialist's knowledge of the potential risks and benefits of the procedure, taking into account the clinical information, and the sensitivity and specificity of the procedure

2.1. The Administering Person

Before any procedure is undertaken, the administering person needs to comply with the centre's operating procedures on how to identify the volunteer/patient

The administering person needs to:

- be trained in intravenous injection and cannulation.
- use protective equipment designed to reduce radiation exposure (e.g. syringe shields, lead pots) and wear an approved personal radiation monitoring device when handling radioactive materials.
- ensure that only persons necessary to the procedure are present when performing administrations; and
- report any instance of accidental, abnormal or unplanned exposure to the HSW/RSO, and where required also in accordance with RMP-S19. (Radiation accident/ incident – reporting process).

2.2. The Nuclear Medicine Technologist

The nuclear medicine technologist is responsible for performing nuclear medicine procedures as prescribed by the nuclear medicine specialist in accordance with the centre's written standard protocols.

This will include one or more of the following duties:

- prepare, dispense and administer radiopharmaceuticals;
- follow imaging and in vitro protocols to ensure optimal data acquisition and analysis;
- perform quality assurance procedures for radiopharmaceuticals, instrumentation and image quality.

The nuclear medicine technologist's role may include the responsibilities of the administering person and the person preparing radiopharmaceuticals.

2.3. The Person Responsible For Radiopharmaceuticals

The person responsible for radiopharmaceuticals needs to develop systems for the:

- procurement of radionuclides/radiopharmaceuticals;
- storage and waste management of radionuclides/radiopharmaceuticals;
- in-house reconstitution of radiopharmaceuticals
- development of standard procedures and safe practices for the preparation and manipulation of radiopharmaceuticals, in consultation with relevant staff;
- implementation of a quality assurance program for radiopharmaceuticals.

The radiopharmacist/radiochemist, plays, in addition to the above duties, a central role in the:

- in-house manufacture of radiopharmaceuticals;
- production of cyclotron radionuclides and derived radiopharmaceuticals;
- implementation of a comprehensive quality assurance program for radiopharmaceuticals;
- and provision of advice on the safe and efficacious use of radiopharmaceuticals.

2.4. The Medical Health Physicist

A Medical Health Physicist is required to be available (See Section 11 on Volunteers) for consultation on optimisation of medical exposures, including clinical dosimetry and quality assurance, and to give advice on matters relating to radiation protection.

The medical health physicist works closely with the nuclear medicine specialist and technologists in the optimisation of clinical studies – through image acquisition, analysis and display optimisation and ongoing oversight of the quality control of equipment.

In addition, a medical physicist is required to provide Human Research Ethics Committees with a radiation dose estimation and risk assessment for any research

studies that involve the research participants receiving an exposure from ionizing radiation, in accordance with the requirements of RPS8, (see RMP S11).

2.5. The Radiation Safety Officer and CRTC

The CRTC/RSO will oversee and provide advice on radiation safety within the Nuclear Medicine Facility.

3. PROCEDURE

3.1. Procedures For Correct Identification Prior To Commencing The Treatment

All personnel must comply with NSW Health Policy Directive *Clinical Procedure Safety, available at:* ***https://www1.health.nsw.gov.au/pds/Pages/doc.aspx?dn=PD2017_032***

The following procedures for ensuring correct patient, procedure and site in Nuclear Medicine are common across NSW:

3.1.1. Step 1 - Referral Document

The volunteer or referral document must be legible and must contain the patient's full name, date of birth and the name of the procedure.

3.1.2. Step 2 – Patient Identification

The patient should be asked to state (not confirm) their full name and date of birth or address.

Questions should be asked in an open ended way, such as 'I need to check your details again; could you please tell me your name and date of birth.'

3.1.3. Step 3: Confirm Procedure

The type of procedure should be checked by asking the volunteer/patient a question such as 'could you also tell me what type of scan you are to have'. If relevant, the administering person should also ask about pregnancy status and confirm the absence of breast-feeding.

3.1.4. Step 4 - "Time Out"

Immediately prior to the administration of the radiopharmaceutical the administering person should confirm that the volunteer/patient identification matches that on the request form; and that the radiopharmaceutical (form and activity) and route of administration are appropriate for the study requested. At least one suitably trained and qualified person should verify the form and activity of the dispensed radiopharmaceutical. For a therapy procedure a second such person is required to verify the measurement of the dispensed activity.

3.1.5. Additional documentation

The person administering the dose to the patient must attach the printout from the dose calibrator for the volunteer/patient's dose to the Request Sheet, complete and sign the printout (indicating pregnancy status and site of injection and other procedural checks), which must stay in the volunteer/patient's Scan Bag.

Procedures To Avoid Unintentional Irradiation of Embryo/Foetus, or Infant

Radiation effects and risks to foetus in Nuclear Medicine.

The risk from radiation is related to the foetal dose and to the stage of pregnancy at which the exposure occurs. Doses above thresholds of 100 mGy or more can cause failure to implant (conceptus up to week 2 or 3 of gestation), developmental abnormalities (embryo weeks 3 to 8) or neurological effects (foetus weeks 8 to 25). There is evidence of a slightly increased risk of induction of childhood cancer or leukaemia for doses of more than 10 mGy. This latter risk is considered to be uniform throughout the pregnancy after the first 3 to 4 weeks of gestation. The life-time cancer risk following intra-uterine exposure is assumed to be similar to that following irradiation in early childhood. In addition to carcinogenesis, radioiodinated compounds can also cause subsequent hypothyroidism in the infant.

Absorbed dose coefficients for the uterus and embryo/foetus from various radiopharmaceuticals administered to a woman in early pregnancy are listed in ARPANSA Safety Guide *Radiation Protection in Nuclear Medicine*, RPS 14.2.

The doses associated with diagnostic nuclear medicine procedures are much lower than the levels where developmental and neurological effects are known to occur. The main physical risk, although very low, may be a slight increased risk of childhood cancer or leukaemia.

Most diagnostic nuclear medicine procedures pose little risk to the mother or foetus compared to other risks during pregnancy. However, anxiety or even distress can occur if a woman has had radiation to the pelvis and subsequently finds that she was pregnant.

Radionuclide therapy procedures can exceed the threshold doses for direct harm to an embryo/foetus.
Sometimes CT is used in combination with radionuclide scanning i.e. with SPECT or PET. The radiation doses from the CT component depend upon the settings used and upon the region of the body scanned.

Confirming Absence of Pregnancy (Diagnostic Procedures)

Illustrated signs are required to be posted in prominent places within the nuclear medicine department, advising volunteer/patients to notify staff if they may be pregnant. An example might read as follows:

IF IT IS POSSIBLE THAT YOU MIGHT BE PREGNANT, PLEASE INFORM THE STAFF **BEFORE** YOU HAVE YOUR INJECTION FOR YOUR NUCLEAR MEDICINE EXAMINATION.

In addition to the signage, staff have a responsibility to enquire about the possibility of pregnancy in all female volunteer/patients of childbearing age. It is required that reasonable steps be taken immediately before the commencement of the procedure to establish whether the volunteer/patient is pregnant. When asking the

volunteer/patient about the possibility of pregnancy it is also important to indicate to the volunteer/patient why there is a need to know, to avoid the volunteer/patient taking offence and not answering fully.

In every case, the volunteer/patient's pregnancy status must be recorded with a signature on the dose printout or worksheet by the injecting technologist or supervising physician.

When doubt exists about pregnancy status, the nuclear medicine specialist should be consulted to make a decision about whether to defer the nuclear medicine study until after the next menstrual period, or to perform a pregnancy test (urinary or serum β-HCG) to confirm absence of pregnancy, or to proceed with the study.

If a β-HCG test is performed and the test is positive, or the result is equivocal, the nuclear medicine specialist should be consulted. If the β-HCG test is equivocal it may be advisable to defer the nuclear medicine procedure for a few days and repeat the test. If a woman whose pregnancy status is uncertain declines β-HCG testing before the nuclear medicine procedure, the offer and refusal should be documented.

Confirming Absence of Pregnancy (Therapeutic Procedures)

The Responsible Person must ensure that there are procedures in place for ascertaining the pregnancy status of a female patient of child-bearing capacity before the performance of any radiological procedure that could result in a dose of 1 mSv or greater to the uterus, so that this information can be considered in the justification for the radiological procedure and in the optimisation of protection and safety. Refer to ARPANSA RPS-C5 Code for Radiation Protection in Medical Exposure and associated Guidelines

Nuclear Medicine Procedures involving pregnant volunteer/patients.

Pregnancy is not an absolute contraindication to radionuclide studies and in many situations, e.g. confirmation or exclusion of pulmonary embolus, may provide essential diagnostic information.

If a diagnostic radiation study is medically indicated the risk to the mother and foetus from not performing the study is usually greater than the risk from the radiation associated with the procedure. If a nuclear medicine study is justified and will be performed, the administered activity should be minimised, provided it is sufficient to supply the required diagnostic information. Prior to the procedure the nuclear medicine specialist should assess the potential dose and communicate the risks to the mother in a meaningful manner. Individual foetal radiation dose estimates may require the services of a nuclear medicine physicist.

The fact that the volunteer/patient is pregnant must be clearly marked on the consultation form.

Avoidance of Conception Following Nuclear Medicine Procedures.

The ICRP has recommended that a woman receiving a therapeutic dose of a radionuclide not become pregnant until sufficient time has passed that the potential foetal dose would not exceed 1 mGy (ICRP 2000a). The female volunteer/patient should be advised to avoid pregnancy for a time period which depends on the isotope and activity administered. These time periods are listed in ARPANSA Safety Guide *Radiation Protection in Nuclear Medicine*, RPS 14.2. Additional advice should be sought from the RSO.

Inadvertent Exposure of a Foetus

All cases of **accidental or unintentional** irradiation of a foetus or embryo must be referred to the Radiation Safety Officer for investigation and assessment.

The RSO should estimate the radiation dose to the foetus so that the volunteer/patient and their obstetrician can then be better advised as to any possible risk. In many cases there is little risk as the irradiation will have occurred in the first 3 weeks following conception. In rare cases the foetus will be older and the dose involved may be significant. It is however extremely rare for the dose to be large enough to warrant advising the volunteer/patient to consider termination.

Breastfeeding or caring for an infant

Illustrated signs are required to be posted in prominent places within the nuclear medicine centre requesting the volunteer/patient to inform the staff if they are breast-feeding, or caring for, an infant. An example might read as follows:

IF YOU ARE BREAST-FEEDING OR CARING FOR A YOUNG CHILD, PLEASE INFORM THE STAFF **BEFORE** YOU HAVE YOUR INJECTION FOR YOUR NUCLEAR MEDICINE EXAMINATION.

Additionally, before commencing a nuclear medicine procedure, every female volunteer/patient of childbearing age should be asked by the administering person whether she is breast-feeding or caring for a young child. Steps can then be taken (if necessary) to minimise the external radiation dose to the child during periods of close contact with the volunteer/patient, and the internal radiation dose from ingested breast milk.

A volunteer/patient who is breast-feeding a child should be advised of the risks of continued breast-feeding before any therapeutic or diagnostic nuclear medicine procedure.

ARPANSA Safety Guide *Radiation Protection in Nuclear Medicine* (RPS14.2) gives advice about the possible need to restrict breast-feeding. The advice to be given to the volunteer/patient will depend on the radiopharmaceutical and its activity, and should ensure that the infant will receive a total effective dose of no more than 1 mSv. Advice should be sought from the RSO.

Breast-feeding should be stopped before commencing therapy with any unsealed radionuclide.

Where interruption of breast-feeding is necessary it may be possible to express some milk prior to the study and to store at least one feed in a refrigerator or freezer. During any period of interruption the mother should regularly express and discard her milk.

ARPANSA Safety Guide *Radiation Protection in Nuclear Medicine* (RPS14.2) also gives advice on the length of time for which a volunteer/patient caring for a child may need to restrict close contact with the child in order to minimise the external irradiation of the child. This advice ensures that the child receives an effective dose of no more than 1 mSv. Advice may be sought from the RSO.

Volunteer/patient related considerations for Radionuclide therapy.

Medical supervision

It is important that the nuclear medicine specialist consults with the volunteer/patient so that clinical issues and possible side-effects of the radiopharmaceutical are discussed. The specialist must supervise the checking of the activity and the administration of the dose.

The ARPANSA publication *Recommendations for the Discharge of Volunteer/patients Undergoing Treatment with Radioactive Substances*, RPS4 provides guidance on the conditions which should be met for the discharge from a hospital or clinic of a volunteer/patient who is undergoing treatment with a radioactive substance, and the conditions for treatment as an outpatient. The recommendations take into account the dose rate external to the volunteer/patient, and the potential for the spread of contamination from an unsealed radioactive substance excreted by the volunteer/patient. The effective dose received by the carer should be unlikely to exceed 5 mSv per treatment episode and the dose to children and members of the public should be unlikely to exceed 1 mSv per annum. Carers are individuals who are not normally occupationally exposed and who are appropriately informed of the radiation risks. Carers may be relatives and friends over the age of 18 years who are not pregnant.

After Radiopharmaceutical Administration

The volunteer/patient and/or their carer should receive written information on:

- the type and radioactivity of the radiopharmaceutical administered;
- the date of administration;
- any specific radiation safety precautions;
- any restrictions on activities including travel home; and
- how long the restrictions or precautions should last.

Further information is available in RPS. 14.2 - Safety Guide Radiation Protection in Nuclear Medicine

Administered Activities And Diagnostic Reference Levels (DRLs)

DRLs for common nuclear medicine procedures have been obtained from a survey of practices in Australia. Reference activities for adult and paediatric volunteer/patients, together with the corresponding effective doses, are available on the ANZSNM website.

The activity of radiopharmaceuticals administered to volunteer/patients must be recorded and periodically compared to diagnostic reference levels (DRLs).

DRLs are advisory, allowing for flexible application to individual volunteer/patients on the basis of sound clinical judgment by the nuclear medicine specialist. However, if a DRL is consistently and substantially exceeded, the usual administered activity should be re-examined to ensure that the activity administered has been optimised.

Technical matters relating to DRLs that should be borne in mind are:

- the DRLs for adults are usually defined for a person of average size, which is taken to be about 70 to 80 kg. When performing dose surveys volunteer/patients within this weight range should be selected.
- recommended values for DRLs are chosen from a substantive survey of the distribution of the activities administered to volunteer/patients. They do not represent best practice, so that the ultimate target for any institution should be to lower their doses to a level regarded as achievable. For any procedure, an achievable activity is one which maximises the ratio of benefit and risk without compromising the clinical purpose of the examination.
- Nuclear Medicine DRL values are reviewed and adjusted from time to time by the ANZSNM .

Volunteer/Patient Radiation Doses from Common Procedures

When considering the justification for a medical exposure, the benefit is weighed against the detriment, including radiation effects. For diagnostic procedures the potential detriment is the risk of inducing cancer. This risk is greater in children and decreases with age. For effective doses greater than 100 mSv the overall lifetime risk of fatal cancer is estimated to be 5% per Sv. Whilst there is no epidemiological evidence of an increased risk below about 100 mSv, using the LNT hypothesis it is possible to extrapolate the risk to lower doses although there is uncertainty in such estimates. An approximate guide is given by age-specific mortality risk factors in a general population. For an effective dose of 20 mSv, the nominal risk is about 1 in 1200 for adults aged 30 to 60 years at the time of exposure.

For adults aged 70 or more the risk falls to less than 1 in 3000. However, for children up to 10 years old the risk is about 1 in 450

The approximate radiation dose range to adults from common diagnostic nuclear medicine procedures is as follows:

Effective Dose Range (mSv)	Procedures
< 1 mSv	GIT motility, lymphoscintigraphy, cystogram, GFR
1-5 mSv	Biliary system, liver/spleen, lung V/Q, renal, thyroid, parotid imaging with ^{99m}Tc
5 – 10 mSv	Bone, parathyroid, GHPS, infection, blood pool, brain or tumour imaging with ^{99m}Tc; tumour imaging with ^{123}I-MIBG
10 – 20 mSv	Myocardial perfusion imaging with all ^{99m}Tc stress/rest protocols; PET/CT , SPECT/CT
> 20 mSv	Infection or tumour imaging with ^{67}Ga; tumour imaging or myocardial perfusion with ^{201}Tl

DOCUMENTATION

As listed in this section.

AUDIT

Review of administered activities every 2 years

REFERENCES

NSW PD2017_032 Clinical Procedure Safety

ARPANSA Safety Guide for Radiation Protection in Nuclear Medicine (2008) (RPS 14.2), ARPANSA 2008

REVISION AND APPROVAL HISTORY

Date	Revision No.	Author and Approval
May., 2014	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
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April 2017	Revision 5	CRTC & William Bartolo
January 2018	Revision 6	William Bartolo
May, 2019	Revision 8	Ms Melissa Musicka & William Bartolo
Sept., 2021	Revision 9	Ms Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Exposure of Volunteers for Research
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S11
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, X-rays, radiology, medical imaging, radiotherapy, research, HREC
SUMMARY *Brief summary of the contents of the document*	Procedure for ensuring that the radiation dose and associated risk for research protocols are clearly and accurately calculated so that they allow proper consideration by the University of Newcastle HREC and the University of Newcastle CRTC before approval and, so that they allow proper consideration by the volunteers or patients to allow informed consent.

INDEX – Section 11

1. BACKGROUND

Research protocols must comply with the Code of Practice - Exposure of Humans to Ionizing Radiation for Research Purposes (ARPANSA Radiation Protection Series Publication No. 8 (May 2005)). This Code of Practice is designed to ensure that researchers proposing to expose research participants to ionising radiation provide the participants and the University of Newcastle HREC and the University of Newcastle CRTC with information that allows consent to be properly considered by the research participants and approval considered by the University of Newcastle HREC and the University of Newcastle CRTC

This Code of Practice applies to research involving healthy volunteers and/or patients who are exposed to radiation which is **additional** to that received as part of any normal clinical management. Thus, it applies to, but is not restricted to, research with diagnostic/therapeutic agents and procedures, including Phase I, II, III and IV clinical trials and novel procedures.

Normal clinical management with regards to radiation is defined as typical or routine radiation management or investigation of a patient.

Knowledge of normal clinical management with regards to radiation is important to proposal preparation because

(a) a proposal might be a modification of normal clinical management with regards to radiation, or;

(b) the volunteer or patient will be exposed during the research to additional radiation due to their normal clinical management.

2. RESPONSIBILITIES

The Chief Investigator

The chief investigator must:

- ensure that the selection of the participants is conducted according to the requirements of RPS 8, the HREC , and the CRTC.
- provide information regarding normal clinical management to the HREC, and the independent assessor (medical physicist). This information on normal clinical management will include:
  - the number of radiation procedures being performed;
  - the frequency or time interval between the radiation procedures; and
  - the anatomical region being exposed to radiation;
- obtain an independent assessment or verification by a medical physicist of the total effective dose and relevant organ doses for those radiological procedures that are performed specifically for the research protocol.
- ensure that the research participant is provided with sufficient written

information in a language that is comprehensible to the volunteer or patient about the purpose, methods, radiation dose, associated risks and any discomforts of the radiation exposure to enable the research participant to give informed consent.

- Ensure that for novel uses of radiation, the actual doses received are calculated or measured

Note: Due to the long latent period associated with certain carcinogenic effects of radiation and the possibility of genetic effects, special consideration must be given to the age, pregnancy status and whether the participant is breast-feeding. Refer to RPS 8 for details.

2.1. The Radiation Safety Officer or Medical Physicist

The RSO or medical physicist must:

(a) independently verify the total effective dose and organ doses and radiation risk assessment which have been provided by the researcher; or

(b) assess the expected total effective dose and organ doses which will be received by the research participant as a result of their participation in the research and the corresponding radiation risks; and

(c) where the dose constraints specified in RPS8 are exceeded, obtain verification of the dose assessment by a second medical physicist who must be independent of the researcher.

2.2. The Human Research Ethics Committee and the Chemical and Radiation Technical Committee

When assessing research proposals involving ionizing radiation the Human Research Ethics Committee and the Chemical and Radiation Technical Committee should work closely together and consider the balance between the likely benefits and risks associated with any radiation exposure including consideration of the advice provided in Annex 1 of RPS8.

PROCEDURE

2.3. Procedure to be followed by the Chief investigator

The chief investigator must

(a) Complete and submit both HREC and safety review applications and obtain aaprovals.

(b) Ensure that the volunteers or patients are given a written description of the procedure and the dose and dose frequency that they received.

(c) Ensure that the volunteers or patients over the age of 13 are advised to retain the written description of the procedure and the dose and dose frequency that they received for at least five years or, in the case of the volunteer or patient being 13 or younger, to keep the records at least to the age of 18. This will

enable the volunteer or patient to provide to researchers or medical practitioners with this information if required.

(d) Ensure that there is a measure or calculation of the actual doses received by the volunteer or patient when the procedure includes novel uses of radiation and report these in accordance with their project approval to the University of Newcastle or HNEAH HREC.

Note: The information on the forms will include:

(a) the reasons why it is necessary to expose research participants to ionizing radiation

(b) the precautions to be taken to keep radiation exposure to a minimum

(c) a statement confirming that the site(s) at which the examination or procedure will be performed is actively involved in a relevant quality assurance program;

(d) for novel uses of radiation, the arrangements for a review and reporting to the CRTC of radiation doses actually received and the arrangements for retention of dose records

(e) the radiation dose assessment and risk assessment obtained from the RSO or medical physicist;

(f) the written information to be given to research participants relating to the doses and risks associated with the radiation exposure.

2.4. Novel Uses of Radiation

In most research, the estimate of the radiation exposure of the research participant determined by the Medical Physicist will be close to the actual exposure received during the research project. This will not necessarily be the case for novel uses of radiation. This type of research will include, for example, the initial use of a new radiopharmaceutical or the initial use of a new radiology imaging device. The dose estimations available to the HREC may have been calculated based on the results of animal experiments or derived using anthropomorphic phantoms. In these circumstances, it is essential that the actual doses received are calculated or measured and should be included in any reports on the project which are prepared by the researcher for the CRTC and Ethics Committee (HREC).

DOCUMENTATION

Safety Review form
HREC Approved Application form

AUDIT

Every 2 years

REFERENCES

Code of Practice - Exposure of Humans to Ionizing Radiation for Research Purposes (ARPANSA Radiation Protection Series Publication No. 8 (May 2005))

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
May 2014	draft	William Bartolo, Bartolo Safety Management Service
March 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	CRTC and William Bartolo
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May, 2019	Revision 8	Ms Melissa Musicka & William Bartolo
Oct., 2021	Revision 9	Ms Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Monitoring
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S12
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REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, X-rays, radioactive substances, radiation monitors
SUMMARY *Brief summary of the contents of the document*	Procedures to ensure that all appropriate staff are issued with, and wear, personal radiation monitors, and that survey meters are maintained and calibrated, including measurement techniques.

INDEX – Section 12

1. BACKGROUND

The NSW Radiation Control Regulation 2013 lists those occupationally exposed persons to whom an employer must provide a personal radiation monitor. This includes those people using radiation in the medium and high level laboratory for research and teaching as well as those people using soil moisture gauges, sealed source devices, and for clinical purposes. The Regulation also requires the employer to provide a copy of the employee's radiation exposure record to the employee when the employee leaves the employer's employment. In addition, the Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (RPS C-5) requires a personal radiation monitor to be provided to each occupationally exposed person (clinical) who is likely to be exposed to ionising radiation in excess of 1 mSv in any one year.

University personnel who are expected to receive greater than thirty percent of the annual recommended effective dose limit of 20mSv should be subject to continuous individual personal monitoring. If the radiation worker is already covered in the legislative list then this radiation worker MUST be issued with a personal dosimeter. Such a person is an 'occupationally exposed person'.

2. RESPONSIBILITIES

Health and Safety Team

The HSW Team in co-operation with the RSO will then:

- ensure that personal radiation monitors are provided (by School or Centre) to all appropriate occupationally exposed personnel;
- ensure the maintenance of the personal dose records of personnel; and
- advise on the selection of a personal dosimetry service.

Area Dosimeter Administrator.

The School or Centre will appoint an Area Dosimeter Administrator. This local area administrator will:

- correspond with the HSW;
- ensure where appropriate that a personal radiation monitor is obtained for each occupationally exposed person;
- ensure that the monitors are promptly sent for processing at the end of each wearing period;
- ensure that the results for each wearing period is given to the badge wearer;
- ensure that a radiation dose record is organised to be given to the worker when they cease to be employed by the organisation; and
- immediately notify the HSW Team whenever a "high" or abnormal dose is recorded or that the badge is lost or damaged; and

- ensure that all dosimetry records and notices are entered into the University dosimetry database (*Historion*) for the central records and for review and action by HSW Team.

Occupationally Exposed Persons

Personnel issued with a personal radiation monitor must:

- wear the monitor in a position appropriate for the work being undertaken;
- wear the badge at all times when working with ionising radiation or in the Designated Radiation Area regardless of whether radiation work is being conducted or not;
- submit their monitor to their administrator for processing at the end of the wearing period; and
- leave their monitor at their place of work after-hours.

PROCEDURE

Personal Radiation Monitors

(a) All personal dosimeters shall be issued, processed and calibrated by a personal monitoring device (PMD) provider approved to do so by the NSW EPA.

(b) Body dosimetry devices are normally worn somewhere on the trunk of the body, such as a collar, lab coat pocket, waist or on a lanyard. However, when working with distinct sources, the dosimeter should be placed in the area of the body most likely to receive the highest amount of radiation exposure.

(c)When not being worn, dosimeters must be stored in an area of low radiation background, such as an assigned locker or office desk drawer.

(d) Dosimeters **SHALL NOT** be taken home.

(e) The local area administrator responsible for a monitored School or Centre must keep the control monitor provided by the dosimetry service in accordance with their instruction. This will be an area of low background radiation levels, normally an office area.

2.1. Electronic Personal Dosimeters

Electronic Personal Dosimeters (EPDs) allow instantaneous measurement of the dose and dose rate. These are used in certain situations where it is necessary to continuously and immediately be able to determine the current accumulated dose. EPDs do not replace the normal personal monitoring devices but can be used in addition to them.

EPDs may also have an alarm operating on a dose rate threshold or an integrated dose threshold. If either alarm does activate it is an indication that the wearer is to immediately cease radiation work and to contact the HSW Team. The HSW Team or

RSO will recommend an EPD to a staff member if electronic monitoring is required. The Local Area Administrator should contact the HSW Team if it is believed that electronic monitoring is required.

2.2. Extremity Monitors

Plastic rings incorporating a radiation monitor are available for staff to request and wear if their hands are likely to be exposed to significant radiation exposure. The ring is normally worn on the index or middle finger of the hand that does the most holding (e.g., for a right-handed person that is usually the left hand) with the active surface on the palm side of the wearer's hand. Dosimeters **SHALL NOT** be taken home.

2.3. Actions to be taken if the radiation doses to workers or the general public are found to exceed the dose constraints

The HSW Team have established the following actions that are to be taken when the dose reported for a personal radiation monitor exceeds certain dose constraints (*see over page*):

Monitoring Period			Action to be taken
4 weeks	**12 weeks**	**26 Weeks**	
-	0.5 mSv to 1.5 mSv	0.5 mSv to 3 mSv	**When dose exceeds 0.5 mSv as notified by dosimetry monitoring company:** The HSW Team will immediately inform the wearer in writing, and investigate and record the circumstances concerning the receipt or possible receipt of the dose. A report must be placed on file in the Faculty. .
0.5 mSv to 1.5 mSv	1.5 mSv to 4.8 mSv	3 mSv to 9.6 mSv	**When dose exceeds 30% of the legal dose limit:** The HSW Team will immediately inform the wearer in writing, and investigate the circumstances concerning the receipt or possible receipt of the dose. The wearer must be asked to submit an incident report form within 5 business days. A report must be submitted to the CRTC and placed on file.
> 1.5 mSv	> 4.8 mSv	> 9.6 mSv	**When dose exceeds the legal dose limit:** The dosimetry monitoring company must report these doses directly to the Radiation Control Section of the EPA, and the University will be required to provide a report of the investigation conducted within seven (7) working days after notice of result. The HSW Team will immediately inform the wearer and RSO in writing and investigate the circumstances concerning the receipt or possible receipt of the dose. The wearer must be asked to submit an incident report form within 3 business days. A report must be submitted to the CRTC immediately and placed on file. The RSO will advise the RML Holder of the exceeded dose and investigation report as soon as the WHS/Committee is made aware.

- *The dosimetry monitoring company highlights doses of 0.5 mSv or higher, regardless of wear period.*
- *These numbers have been set by the CRTC and are based on laboratory averages, the industry standard 30% notification threshold and the internal rule set by the NSW EPA that recommends organisations set their action and investigation levels below what the regulatory authority would work at, to ensure the health and safety of employees and other persons for which they have a duty of care. For further advice or information, please refer to ICRP 103 and the IAEA General Safety Requirements Part 3, or contact the EPA.*

3. RADIATION DETECTOR/SURVEY METERS

A radiation detector/survey meter is required to undertake radiation checks or surveys. A detector/survey meter is considered appropriate for use if it:

(a) has sufficient measurement range to measure ambient dose equivalent rates at least throughout the ranges of 0.5 $\mu Sv \cdot hr^{-1}$ to 1 $mSv \cdot hr^{-1}$ from the radioactive sources used.

(b) continues to indicate, either visibly or audibly, when radiation levels exceed the maximum reading in any measurement range; and

(c) indicates the measured quantity with a measurement uncertainty not greater than ± 25% inclusive of uncertainty due to response variation with energy over the range of energies of the radiation to be measured.

Radiation monitor/survey meters must be calibrated annually at an appropriate calibration facility.

Documentation must be kept by the Chief investigator or an assigned project or facility representative of all calibrations, problems, repairs and services.

4. RADIATION TESTING AND AREA SURVEYS

Refer to RMP Section 6 for details on monitoring in areas where X-ray analysis Equipment is located and used.

4.1. For Surface contamination.

4.1.1. Portable Detector Method

(a) **Select** a portable detector and determine the following information about the detector:
i). Type;
ii). Sensitivity; and
iii). Efficiency.

(b) **To scan** the surface hold the detector probe approximately 5 cm from and perpendicular to the surface and move the probe over the surface in a regular organised fashion to cover the whole surface of the structure.

(c) When a site of contamination is located, define the edges, or extent, of the spill and mark out the contaminated area using chalk or some other removable marker. Roughly estimate the activity of the spill. And then Decontaminate as appropriate.

4.1.2. Wipe (Smear) Test method

Determine the approximate surface area of the features (viz., bench top, sinks, etc) and what area in square metres is to be tested with each fitter paper. Divide the area into sampling segments of 10 x 10 cm and allocate each area an identifying code.

Supplies

- Laboratory Coat
- Disposable Gloves
- Scissors
- 4cm Filter Papers
- Scintillation Vials

- Scintillation Fluid
- Marking Pen
- Coloured Chalk

Methodology

- Wearing double gloves, wipe the surface of each sampling segment with the dry filter paper. Count the filter papers for at least 30 seconds using either a very good contamination meter that is appropriate for the isotope or a scintillation counter.

- **If a Scintillation Counter or Gamma counter is being used conduct the following**: When the area of the segment has been sampled, cut the filter paper into fragments to fit the scintillation vial. Place into the vial and add scintillation fluid. Mark the lid with its identifying code.

- Once all the sampling segments are done and the scintillation vials are complete, make up a control vial using a clean filter paper.

- Count for 5 minutes per vial (should be for at least 1 hour per vial for better accuracy) and determine the areas contaminated and then apply the following formula on the scintillation counter data. Remember from the theory to incorporate the counter efficiency and any other details that may need to be considered for the determination.

- **With results from either method,** apply the formula and determine whether the bench areas are contaminated.

The contamination level can be calculated from the formula:

contamination level (Bq/m^2) = C_c x ($100/E_c$ x ($1/A$) x ($100/E_F$)

where
C_c = count rate, corrected for background, in counts per second
E_c = overall percentage efficiency of the counting system
A = area smeared in M^2
E_F = percentage of the contamination picked up by the paper

The last quantity, E_F, is quite difficult to determine and is not reproducible. It is dependent on various parameters, such as physical and chemical nature of the contamination, the nature of the base surface and so on. In some circumstances E_F is taken as 100% and in these cases it is the 'removable' contamination which is being determined. More usually a figure of 10% is assumed.

Is the bench contaminated, using the level of 4Bq /Cm^2 and greater as being contaminated?

Note: The 4Bq /Cm^2 is not the regulatory level or the level used in the Australian Standard. The regulatory level for this isotope is 1 x 10^9 and the Standard uses DWL's as the levels for contamination. The RSO uses the level that the NHMRC had used in one of their publications (now outdated) which is 10^3 Bq/cm^2. The reason being is that most laboratory portable detection meters will not discern very low levels from the general background level.

4.2. For Storage locations.

As for above for detector instrument method and measure all external accessible surfaces of the storage location.

4.3. For Area Monitoring.

As above with monitoring instrument but measure the dose rates in the general areas throughout the DRA.

5. DOCUMENTATION

Personal radiation dose records

Area/Contamination/Storage dose records

Radiation Instrument Records (service, repairs and calibration)

6. AUDIT

None

7. REFERENCES

ARPANSA Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (RPS C-5)

NSW Radiation Control Regulation 2003

8. REVISION AND APPROVAL HISTORY

(state the author of the document, the date it was written, its revision number and approval history)

Date	Revision No.	Author and Approval
May 2014	draft	William Bartolo, Bartolo Safety Management Service
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INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Calibration and Quality Assurance Procedures
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S13
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, radiology, medical imaging, nuclear medicine, calibration, quality assurance
SUMMARY *Brief summary of the contents of the document*	Procedure for the calibration and quality assurance of equipment used in medical imaging, nuclear medicine and radiation monitoring.

INDEX – Section 13

1. BACKGROUND

This document provides procedures necessary to ensure compliance with this policy in relation to the calibration and quality assurance of equipment used in medical imaging, nuclear medicine and radiation monitoring. This is to ensure compliance with the current legislation as well as NSW Guideline No.1, NSW Guideline No.6, ARPANSA RPS 14, ARPANSA RPS 6, ARPANSA RPS 10, and ARPANSA RPS 17.

From time to time random inspections of equipment and procedures take place and to pass these inspections it is essential that proper records are kept regarding calibration of instruments.

2. RESPONSIBILITIES

Radiation Management License Holder

In accordance with the ARPANSA Medical Code of Practice (RPS14), the Chief Executive (in NSW this is the Radiation Management Licence (RML) holder or the delegate) must ensure that a comprehensive equipment Quality Assurance program is established, performed, maintained and regularly reviewed at any site where radiation-producing equipment or radioactive sources are used.

The RML Holder may delegate to the Associate Director, Employee Relations and Work, Health and Safety the process and record keeping, but not the responsibility for a QA program and that it is performed maintained and regularly reviewed in the future.

The Chief Executive must, following any repair, maintenance or modification on radiation-producing equipment, or equipment containing radioactive source(s), that could impact radiation safety, ensure that:

(a) the operation of the equipment is re-assessed so that the radiation safety of patients, staff and the public is maintained; and

(b) a radiation survey is carried out by the RSO or a medical physicist.

2.1. The Radiation Safety Officer or Medical Physicist

The RPA/RSO or medical physicist must undertake or oversee the calibration and quality assurance program, and carry out any radiation surveys that are required.

2.2. The Radiographer or Nuclear Medicine Technologist

The radiographer or nuclear medicine technologist must undertake the calibration and quality assurance program according to the protocols approved by the RPA/RSO or medical physicist.

PROCEDURE

2.3. Calibration, Acceptance And Tests Of Radiation Apparatus

All diagnostic and interventional X-ray equipment used must be registered with the NSW EPA via inclusion in the Radiation Management License Schedule/Inventory. To be registered, the equipment must pass a series of compliance tests performed by a Consulting Radiation Expert (CRE) who has been accredited by the EPA for the particular class of equipment (mammography, dental, general radiography, etc). The requirements for compliance and registration are specified in NSW Radiation Guideline 6 *Requirements for ionising radiation apparatus used in diagnostic imaging*

All new X-ray equipment must be tested for compliance using the test protocols in part 6 of this guideline. Any deficiencies identified by the CRE must be corrected and retested by the CRE before the equipment can be used clinically.

NOTE: Ongoing compliance testing will be required either 2 or 5 yearly. Equipment which produces relatively high doses, such as CT scanners, require testing every 2 years, while low-dose equipment, such as bone densitometers, have a 5-yearly testing requirement.

2.4. Repair And Maintenance Of Radiation Apparatus

Diagnostic and interventional radiation apparatus must only be repaired by qualified service engineers who possess a current radiation licence. Whenever the repair may have compromised the imaging performance of the equipment or any of the radiation safety features the relevant compliance tests must be repeated and passed successfully before the equipment is reused clinically. If the X-ray tube, housing or generator is replaced, the full compliance tests must be performed and the Certificate of Compliance issued and retained by the RML Holder. The new components must also be registered on the RML and disposed components removed from the RML.

The RML Holder must, following any repair, maintenance or modification on radiation-producing equipment, or equipment containing radioactive source(s), that could impact radiation safety, ensure that:

(a) the operation of the equipment is re-assessed so that the radiation safety of patients, staff and the public is maintained; and

(b) a radiation survey is carried out by a medical physicist.

2.5. Radiology Quality Assurance

2.5.1. Acceptance Testing

At installation, a series of acceptance tests shall be performed to define the acceptable range of parameters that will be monitored in the subsequent constancy tests. The compliance tests necessary for equipment registration will form part of the acceptance tests.

2.5.2. Constancy Testing

Constancy tests designed to assess the subsequent performance of the equipment, image quality and patient dose should be performed at regular intervals. The following table of testing frequencies has been recommended by the ACPSEM (Recommendations for a technical quality control program for diagnostic X-ray equipment)

Category of Equipment	Recommended Interval Between Tests
Mammographic, CT and fluoroscopic X-ray apparatus (Fixed or mobile).	6-12 months
General radiographic X-ray apparatus (including dental OPG and cephalometric)	12 months. (Maximum 24 months)
CR/DR image receptors and other image processing systems	12 months
Dental (intra-oral) and DEXA	36 months

The frequency of inspection recommended for the different classes of equipment is seen as a compromise between the potential for injury to individual patients undergoing imaging based procedures, the inherent reliability of different modalities and the cost and inconvenience of testing.

The RANZCR, in its Standards of Practice for Diagnostic and Interventional Radiology, Version 9, require the following minimum equipment quality control:

“8-2-2 BMD Equipment Quality Control
The radiology unit performing BMD must comply with the quality control requirements of the Accreditation Guidelines for Bone Densitometry, published by the ANZBMS (2018)”. This requires:

- Quality control procedures are documented and kept within the vicinity of the equipment
- All tests are recorded and kept within the vicinity of the equipment
- At time of installation, machine calibration and testing by supplier. Accuracy and precision evaluation:
  - In vitro: short-term precision
  - In vivo: short-term precision
- Calibration and quality control according to manufacturer’s specifications. The QC phantom shall be scanned at least twice weekly (and preferably daily) using the same scanning parameters. This phantom is not the daily calibration phantom, but is an anthropomorphic (or quasi-anthropomorphic) phantom recommended by (or at least acceptable to) the manufacturer.

“9-1-1 CT Performance Testing

The practice shall as a minimum undertake all quality control requirements as determined by the manufacturer including maintenance and calibration.”

“9-3-4-2 CT Dose

The practice unit maintains and regularly reviews CT scanning protocols which are optimised to limit patient radiation exposure.

Where the CT unit being used is capable of displaying DLP or CTDI figures, the practice shall review CT patient dosimetry for specific common scan protocols, and shall document the typical dose length product for the specified protocols. These documents are to be kept in the vicinity of the apparatus.”

“10-3-2-1 General X-Ray Image Review - Plain Film

The practice unit shall ensure that X-ray repeats are monitored and reviewed in adherence to the ALARA Principle.”

“10-3-2-2 CR/DR Performance Testing

The practice shall maintain a Quality Assurance (QA) program specifically designed to assess the performance of its CR/DR equipment. The radiology unit shall as a minimum follow the manufacturer's recommended QC program.

An acceptable QA program must, as a minimum, include:

- Must keep in the vicinity of the equipment and maintain dose output records (to commence from acceptance testing) and reviewing dose optimisation at least 6 (six) monthly ensuring that any general increase in dosage levels is identified and examined, and where required corrected; and
- Conducting analysis of repeats and recording findings and corrective and/or preventive action taken.”

“10-4-1 Radiation Safety - Fluoroscopic Examinations

A log must be kept near the apparatus and maintained of screening times and (where the fluoroscopy equipment is capable of this) dose for all fluoroscopic examinations.

Corrective action shall be taken as necessary to minimise patient exposure.”

“13-2-2 Diagnostic Mammography Quality Control for Film Screen Mammography Units

There must be documented procedures for quality control checks as specified in the ACPSEM Standard for Facility Quality Control Procedures” (Craig AR et al, *Recommendations for a mammography quality assurance program*, *Appendix 1*, Aust Phys Eng Sci Med, 2001, 24:107-131).

"13-2-3 Diagnostic Mammography Annual Equipment Testing

Mammography equipment must be tested annually in accordance with the ACPSEM Standards for Mammography System Performance and Medical Physics Testing" (Craig AR et al, *Recommendations for a mammography quality assurance program*, *Appendix 2*, Aust Phys Eng Sci Med, 2001, 24:107-131).

"13-2-4 Diagnostic Mammography Annual Equipment Testing - CR/DR Mammography Equipment

Computed radiography (CR) and full field digital (DR) mammography equipment shall be tested in accordance with the manufacturer's guidelines, and the RANZCR Mammography Quality Assurance Program (CR/DR)."

"13-6-1 Mammography Radiation Dose Limit

The practice must not exceed the Mammography Radiation Dose Limit requirements of the RANZCR Mammography Quality Assurance Program.
The average glandular dose as determined by the dosimeter must not exceed 2 mGy (200 mrad) per view, using the RMI-156 phantom or another of equivalent constitution."

2.6. Calibration, Acceptance And Tests Of Nuclear Medicine Equipment

Nuclear Medicine Quality Assurance programs focus on image quality, radiopharmaceutical quality and patient dose optimisation.

The basic elements consist of:

(a) equipment acceptance testing;

(b) equipment constancy testing;

(c) radiopharmaceutical quality testing;

(d) record keeping;

(e) patient activity surveys; and

(f) keeping records of equipment unscheduled downtime and the reason for the failure.

Acceptance Testing of Nuclear Medicine Equipment

At initial installation, the nuclear medicine equipment (e.g. radionuclide dose calibrators, gamma cameras, PET cameras, autogamma counters, laser film imagers) need to undergo acceptance testing to ensure that the equipment performance complies with the manufacturer's specifications and also to establish a baseline against which future equipment performance can be evaluated. The results of the acceptance testing will need to be documented with a copy sent to HSW, and be available for inspection by the relevant regulatory authority.

Any radionuclide sources used in performing accuracy checks of radionuclide dose calibrators will need to have a calibration traceable to a national or international standard.

2.7. Repair And Maintenance Of The Nuclear Medicine Equipment

Nuclear Medicine equipment must only be repaired / maintained by qualified service engineers who possess a current radiation licence covering the use of radioactive substances for quality assurance purposes.

Following calibration or repair (prior to clinical use), equipment performance must be assessed to demonstrate that it is at a level which equals or is better than that expected for routine performance of clinical work. This judgement would be made by comparison of the equipment performance to baseline or recent quality control assessments.

2.8. Nuclear Medicine Quality Assurance, Including Radiopharmaceutical QA

Local QA programs should clearly define the:

(a) types of constancy tests;

(b) frequency of tests;

(c) tolerance of each parameter being monitored; and

(d) procedure for staff to follow when tolerance is exceeded and this procedure must include:
- Review of the results of constancy testing need to be a matter of routine, and
- any anomalous results reported immediately to the Responsible Person, usually HSW.

Tests designed to assess the performance of the equipment must be conducted, taking into account:

(a) the likelihood of an equipment failure or a measured parameter falling outside an acceptable tolerance range; and

(b) the frequency of testing based on the consequences that follow when such an event occurs.

Gamma Cameras

Suggested Gamma Camera tests and frequencies are outlined in the document "Minimum Quality Control Requirements for Nuclear Medicine Equipment," prepared by the Technical Standards Committee of the Australian and New Zealand Society of Nuclear Medicine (ANZSNM) and available for ANZSNM Members at:
http://www.anzsnm.org.au/resources/technical-standards/

PET Equipment

For PET equipment, the Technical Standards Committee of the Australian and New Zealand Society of Nuclear Medicine (ANZSNM) have produced the document "Requirements for PET Accreditation (Instrumentation & Radiation Safety)" which

outlines Minimum performance parameters for the PET scanner in an accredited PET facility measured using NEMA NU2-2001 protocols.

This is available at:
http://www.anzsnm.org.au/resources/technical-standards/

Current required performance parameters are as follows:

Parameter	***Specification***
Axial resolution at 1 cm radius£6.5 mm Transverse resolution at 1 cm radius	≤ 6.0 mm
Transverse (tangential) resolution at 10 cm radius	≤ 8 mm
Axial resolution at 10 cm radius	≤ 8 mm
System sensitivity	≥ 4.0 cps/kBq
Maximum count rate error over the central 80% of axial FOV (after dead time correction) at or below NEC_{peak}‡30 kcps Peak noise equivalent count rate (NECpeak) at activity concentrations of £10 kBq/ml	≤ 10%

Testing of Dose Calibrators

For dose calibrators, the following tests shall be conducted at the frequency indicated below, and to the indicated tolerance:

(a) background – at least once each work day prior to the first assay of patient dosages or whenever contamination of the dose calibrator is suspected;

(b) constancy – at least once each work day prior to the first assay of patient dosages (±10 per cent);

(c) linearity – at installation and at least annually thereafter, and after repair or movement (±10 per cent);

(d) accuracy – at installation and at least annually thereafter, and after repair or movement (±10 per cent); and

(e) geometry independence – at installation and after repair or movement (±10 per cent).

Recommended testing frequencies for dose calibrator quality control procedures are as follows:

Quality Control Procedure	**Testing Frequency**
Constancy	Daily
Linearity	Annually
Accuracy	Annually
Geometry independence	At calibrator acceptance and then for any change in sample geometry

Repair, replacement, or arithmetic correction will need to be conducted if the dose calibrator falls outside the indicated tolerances.

Details of procedures that may be used to meet these test requirements are provided in *ARPANSA's Radiation Protection Series No. 14.2 Safety Guide Radiation Protection in Nuclear Medicine.*

Testing Radiopharmaceutical Quality

The in vivo behaviour of a radiopharmaceutical is dependent upon its quality, which includes high standards of radionuclidic, radiochemical and chemical purity. The specifications and quality control testing for most of the currently used radiopharmaceuticals are given in the British Pharmacopoeia (BP) or other suitable Pharmacopoeia (e.g. USP). There should be written local procedures detailing all aspects of quality control testing that should be considered before the radiopharmaceutical is administered to the patient.

Technetium-99m Generator

A molybdenum-99 breakthrough measurement needs to be performed on all elutions from each technetium-99m generator and the following records kept of all generator elutions:

(a) dose calibrator setting where the isotope is manually dialled;

(b) reading of long-lived reference source;

(c)time of elution;

(d) volume of eluate;

(e) technetium- 99m activity;

(f) molybdenum-99 activity; and

(g) radionuclidic purity.

BP specification for molybdenum-99 impurity in sodium pertechnetate eluate is 0.1% or a limit of 1 MBq of molybdenum-99 per GBq of technetium-99m at the time of administration. If this level is exceeded, then the technetium-99m solution has failed quality control and is not to be used in the preparation of radiopharmaceuticals for patient use. (Note: The US pharmacopoeia limit of 0.15 MBq Mo-99 per GBq Tc-99m may also be used).

Aluminium ion breakthrough should also be checked on any eluate used to prepare products that are adversely affected by the presence of aluminium.

Technetium-99m cold kits.

The procedure for using technetium-99m prepared from cold kits shall include any appropriate radiochemical purity testing to be performed on the reconstituted kit

prior to patient administration. Records of such testing are to be maintained and kept.

2.9. Use, Maintenance And Calibration Of Radiation Measuring Instruments

Proper radiation survey meters must be used for each radiation survey required by this Plan. A survey meter is considered proper if it:

(a) has sufficient measurement range to measure ambient dose equivalent rates at least throughout the ranges of 0.5 µSv hr^{-1}, or its equivalent, to 1 mSv hr^{-1} (2 mSv hr^{-1} for radiotherapy use) or its equivalent from the radioactive sources used.

(b) continues to indicate, either visibly or audibly, when radiation levels exceed the maximum reading in any measurement range; and

(c) indicates the measured quantity with a measurement uncertainty not greater than ± 25% inclusive of uncertainty due to response variation with energy over the range of energies of the radiation to be measured.

Radiation survey meters used for the purposes of completing 3.7.1 above must have an operational and calibration check performed:

(a) Prior to initial use;

(b) At intervals not exceeding 12 months; and

(c) Following damage or repairs.

VETERINARY RADIOLOGY QUALITY ASSURANCE

2.10. Quality assurance program

A quality assurance (QA) program approved by a CRE should be instituted and maintained with a copy sent to HSW.

The program should ensure that consistent, optimum-quality images are produced so that the exposure of operator, staff and the general public to radiation satisfies the ‘as low as reasonably achievable’ principle.

QA procedures should be standardised and documented in a QA manual.

2.11. Ongoing testing

The QA program should include checks and test measurements on all parts of the imaging system, as indicated in NSW Guideline 6 Part 4 and in ARPANSA RPS 17, at appropriate time intervals not exceeding one year.

The program should include daily step-wedge or equivalent quality control of the electronic output of X-ray film processors.

DOCUMENTATION

None

AUDIT

Every 2 years

REFERENCES

ARPANSA Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (2019), RPS C-5

ARPANSA **Radiation Protection in Veterinary Medicine** (2009), RPS17

ARPANSA Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology (2008), RPS14-1

ARPANSA Safety Guide for Radiation Protection in Nuclear Medicine (2008), RPS14-2

ARPANSA Safety Guide for Radiation Protection in Radiotherapy (2008), RPS14-3

ANZBMS Accreditation Guidelines for Bone Densitometry (2007)

ANZSNM Minimum Quality Control Requirements for Nuclear Medicine Equipment (1999)

ANZSNM Requirements for PET Accreditation (Instrumentation and Radiation Safety)

RANZCR,, Standards of Practice for Diagnostic and Interventional Radiology

NSW Radiation Guideline 6 Requirements & industry best practice for ionising radiation apparatus used in diagnostic imaging.

ACPSEM Position Paper: Recommendations for a technical quality control program for diagnostic X-ray equipment, Aust Phys Eng Sci Med, 2008, 28:69-75

Craig AR et al, Recommendations for a mammography quality assurance program, Aust Phys Eng Sci Med, 2001, 24:107-131

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
May 2014	draft	William Bartolo, Bartolo Safety Management Service
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April, 2017	Revision 5	CRTC & William Bartolo
January 2018	Revision 6	William Bartolo
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RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Management of Radiation Apparatus
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S14
DATE OF PUBLICATION	
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LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	Nil
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, x-rays, radiology, medical imaging, radiotherapy, equipment management
SUMMARY *Brief summary of the contents of the document*	Procedures for the maintenance, disposal and reporting of faults of radiation apparatus.

INDEX – Section 14

1. BACKGROUND

This document provides procedures necessary to ensure compliance with this policy in relation to the management of equipment used in medical imaging, nuclear medicine and radiation monitoring. This is to ensure compliance with the current legislation as well as NSW Guideline No.1, NSW Guideline No.6, ARPANSA RPS C-5, ARPANSA RPS 6, ARPANSA RPS 10, and ARPANSA RPS 17.

From time to time random inspections of equipment registers and documentation will take place to ensure the necessary documentation and records are kept and maintained.

2. RESPONSIBILITIES

2.1. The University Radiation Management Licence Holder

The University via the Radiation Management Licence Holder alone is responsible for the disposal of radiation apparatus and for ensuring that records of disposal are maintained.

The University via the Radiation Management Licence Holder will be responsible for ensuring that

(a) the repair, maintenance, disposal or sale of radiation apparatus comply with the NSW Radiation Control Regulation 2013.

(b) copies of all maintenance and inspection reports and summaries of QA tests undertaken on radiation apparatus, together with a copy of the registration certificate are kept with the apparatus and copies are sent to HSW.

(c) annual and random inspections in regards to the management of this apparatus are conducted by HSW.

Note: The records may be in hardcopy or electronic form.

Note: The records must be kept for at least 5 years and made available on request to an authorised officer of the EPA. They can only be disposed of after permission is granted from the State Director General.

2.2. The Radiation Management License Holder and the Chief Investigator/Responsible Academic

Both the RML Holder responsible for the instrument and chief investigators using the instrument must ensure compliance with the following procedures relating to the repair, maintenance, disposal or sale of radiation apparatus. Normally, the process would occur jointly between these parties.

PROCEDURE

2.3. Repair And Maintenance Of Radiation Apparatus

Radiation apparatus must only be repaired and maintained by qualified service engineers who possess a current radiation licence and whose licence allows them to repair the specific radiation apparatus.

HSW will be informed by the chief Investigator/responsible academic using the instrument of intended maintenance, inspection or intended repair and the details of the person or company carrying out the work prior to the work taking place.

Whenever the repair and maintenance may have compromised the performance of the equipment or any of the radiation safety features, the relevant compliance tests must be repeated and passed before the equipment is reused either for research or clinically.
If an X-ray tube of a clinical unit is replaced, the full compliance tests must be performed by a CRE.

HSW will be sent a report by the Chief Investigator/Responsible Academic responsible for the instrument that will include the date of completion and an overview of the maintenance, inspection or repair as soon as possible following the work. It will include the name of the person or company who carried out the work.
For repairs needing compliance tests, a Certificate of Compliance must be sent to HSW and a copy maintained at the site of the unit.

Where the CRE has certified the apparatus as compliant, but has specified that minor repairs are necessary to satisfy all the registration requirements, the Chief Investigator/Responsible Academic responsible for the instrument must:

(a) inform the HSW of the need for these repairs and the specified timeframe.

(b) ensure that these repairs are carried out within the timeframe specified in the CRE's report; and

(c) adhere to any restrictions in the use or operation of this apparatus specified by the CRE until the apparatus is fully repaired.

(d) Inform the HSW in writing when the repairs have been completed

2.4. The Reporting Of Faults That Would Compromise Safety, Diagnosis Or Analysis

2.4.1. The Chief Investigator/Responsible Academic responsible for the instrument will:

(a) Report to HSW any suspected problems with a unit of ionising equipment that have or may present a health hazard.

(b) notify the HSW within 2 days if the radiation apparatus:
i).fails or ceases to satisfy the requirements for registration;
ii).has an X-ray tube insert replaced; or
iii). is relocated (fixed units only).

2.4.2. HSW will:

(a) Report to the RML holder any suspected problems with a unit of ionising equipment that have or may present a health hazard.

(b) notify the RML holder within 4 days if the radiation apparatus:
i). fails or ceases to satisfy the requirements for registration;
ii). has an X-ray tube insert replaced; or
iii). is relocated (fixed units only).

2.4.3. The RML holder will:

(a) Ensure that any suspected problems with a unit of ionising equipment that have or may present a health hazard are reported to the Therapeutic Goods Administration (TGA) or the EPA depending on the classification of the equipment.

(b) Ensure that the EPA is informed within 7 days if a radiation apparatus:
i). fails or ceases to satisfy the requirements for registration;
ii). has an X-ray tube insert replaced; or
iii). is relocated (fixed units only).

Note: Typical problems include deficiencies in labelling, instructions or packaging, defective components, performance failures, poor construction or design.

Note: Details of how to report the problem can be found at the TGA website .

2.5. Disposal Of Radiation Apparatus

2.5.1. The Investigator responsible for the instrument will notify HSW:

(a) of an intention to dispose of radiation equipment

(b) when the radiation apparatus has been rendered permanently inoperable (a condition of disposal) and “safe; and

(c)only dispose of the equipment following written approval by HSW;

2.5.2. HSW will notify the RML Holder:

(a) the intention to dispose of radiation equipment.

(b) when the radiation equipment has been disposed

2.5.3. The RML holder will ensure that the EPA has been notified within 21 days using the RML variation procedure on the EPA eConnect website

2.6. Trade Of Radiation Apparatus

The RML Holder may trade radiation apparatus only if:

(a) the RML has a condition of licence to sell/possess radiation apparatus, or an appropriate licence to use the apparatus; and

(b) the EPA has been notified within 21 days using the RML variation procedure on the EPA eConnect website.

2.7. Transfer Of Registration

The RML Holder may transfer the radiation apparatus to another person only if:

(a) the purchaser holds a licence to sell/possess radiation apparatus, or an appropriate licence to use the apparatus; and

(b) The University Equipment Disposal has been appropriately authorised.

DOCUMENTATION

The University Asset Disposal form
EPA RML variation Procedure on the EPA eConnect Website

AUDIT

Annual audit of equipment registrations

REFERENCES

NSW Radiation Control Regulation 2013

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
May, 2014	draft	William Bartolo, Bartolo Safety Management Service
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INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation shielding & facility design
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S15
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation shielding, facility design, building construction
SUMMARY *Brief summary of the contents of the document*	Shielding and facility design procedures to limit radiation risk to staff and members of public.

INDEX – Section 15

1. BACKGROUND

University of Newcastle uses radiation for various scientific and medical purposes. Such activities require radiation shielding, facility design and storage of radioactive materials such that they comply with the requirements of NSW *Radiation Guideline 7 – Radiation Shielding Design Assessment and Verification Requirements.*

This means that all areas where radiation is to be used need to be assessed to determine if shielding is required and to ensure that the shielding is adequate for the particular use. Shielding should be a central part of design from the earliest stages of facility and project planning.

This process also includes the need to reconsider the adequacy of shielding in existing radiation facilities when building modifications or increased building occupancy result in changes to previously unoccupied space adjacent to radiation facilities or sources.

2. DEFINITION

Facility is the building, room or space where the activity occurs and any adjacent spaces that could be affected by the activity or sources. Laboratory is defined as an area where scientific endeavour occurs.

3. RESPONSIBILITIES

3.1. Senior Technical Officer

The most senior technical officer that is responsible for a facility or the equivalent person in another functional division of the university that is responsible for a facility, e.g. the Senior Manager of Capital Works will:

(a) ensure that the Radiation Safety Officer is consulted prior to development of any new facility

(b) ensure that the Radiation Safety Officer is consulted prior to any modifications to existing buildings and facilities which incorporate radiation sources.

(c) ensure that records are kept of the consultation. These records will include recommendations from the RSO or other professional consultants and the actions taken regarding the recommendations.

(d) ensure that records of consultation are submitted to HSW within two weeks of any such meetings.

Radiation Safety Officer

The RSO will have suitable qualifications and experience in shielding design for the particular type of facility involved, or else an expert with qualifications and experience in shielding design for the particular type of facility involved must be consulted.

The RSO will assess the advice from consultants for accuracy and verify (via a professional consultant if necessary) that the shielding is implemented correctly during and after construction.

Chief Investigator/Responsible Academic

The Chief Investigator/Responsible Academic will ensure that the facility has adequate shielding and storage facilities for the activity being undertaken.

Works Project Officer

The Works Project Officer will be responsible for ensuring that the design of the works complies or exceeds the legislative requirements and:

(a) The RSO & CRTC approves the design;

(b) That copies of the testing and certification results of the facility are provided to the RSO & CRTC; and

(c) That the facility is not handed over until the RSO has approved the 'structural' elements of the facility.

PROCEDURE

3.2. Project Planning

(a) Arrange radiation activities within a facility to reduce the amount of shielding required.

(b) Consult with RSO from earliest planning stages.

(c) Consider the type of analysis being undertaken.

(d) On advice from the RSO an independent Consulting Radiation Expert (CRE) specialising in shielding will be engaged as part of the design team.

(e) If a health physicist is responsible for the operation of a facility then they should be part of the design team from the earliest stages.

(f) Shielding must comply with NSW EPA guideline *Radiation Guideline 7 – Radiation Shielding Design Assessment and Verification Requirements*.

3.3. Design considerations to comply with dose constraints

To not exceed dose limits for the members of the public and occupationally exposed persons as described in Schedule 2 of the NSW Radiation Control Regulation 2013, the shielding design:

(a) should ensure that radiation levels in facilities do not give rise to an equivalent dose greater than 100 µSv per week for occupationally exposed persons from all sources of exposure

(b) **must** ensure that radiation levels in facilities do not give rise to an equivalent dose greater than 20 µSv per week for members of the general public.

3.4. Planning of Radiology Facilities

General considerations for the planning of radiology facilities (including X-ray analysis, diagnostic X-ray apparatus) include:

(a) intended volunteer/patient workload

(b) the type of clinical examinations to be undertaken, or

(c) the type of analysis being undertaken.

Further design and shielding assessments should be undertaken when:

(a) the intended use of a room changes;

(b) X-ray equipment is upgraded;

NOTE: Further details of specific shielding requirements for medical applications can be found in NSW EPA *Radiation Guideline 6 – Registration requirements and Industry best practice for ionising Radiation apparatus used in diagnostic imaging.*

NOTE: The literature (NCRP 2004, BIR 2000) should be referred to for advice on structural shielding issues.

NOTE: As a general requirement, RPS C-5 requires that barriers should:

- be at least two metres high; and
- have all penetrations and joints arranged so that they are equally as effective in shielding radiation.

(a) Any viewing windows need to have at least the same lead equivalence as the minimum shielding specifications for the shielded barrier in which they are located.

(b) Due consideration should be given to the provision of floor and or ceiling shielding when rooms immediately below and above the X-ray installation respectively are occupied.

(c) Where estimating shielding for CT installations, the Qualified Expert (Shielding Physicist) should insist that the equipment suppliers provide radiation scatter contour maps around the scanner as part of the documentation accompanying the equipment.

(d) Appendix C of NSW EPA *Radiation Guideline 7* should be consulted for further technical details relating to shielding of diagnostic X-ray facilities.

(e) All shielded barriers must be labelled with the details of the shielding as per EPA Radiation Guidelines 6 and 7. These labels should preferably be provided by the company constructing or providing the shielding and must specify the lead equivalent of the shield and the energy at which that lead equivalence is defined.

(f) When dictated by Radiation Guideline 7 an independent CRE should ensure that a radiation survey is undertaken to confirm the shielding meets the relevant

requirements.

(g) A documented record of this assessment must be kept as part of the facility commissioning records. Radiation Guideline 7 should be consulted for the essential elements required in this record.

3.5. Planning of Unsealed Source Facilities

Consult with the RSO and HSW to confirm the facility and laboratory grading (low, medium, or high) as described by the legislation and AS2243.4 and follow the general guidelines found in AS2982 and AS2243.4

For high level facilities security arrangements may be required to be incorporated into the design.

3.6. Low-Level Laboratories

In low-level laboratories, fittings and finish shall be chosen so that they may be readily, cleaned and shall incorporate features as follows:

(a) Joints shall be sealed and made waterproof and be located away from sources of contamination (e.g. not near sinks or under edges of benches).

(b) Seamless PVC flooring is recommended. Painted or carpeted surfaces are not acceptable.

(c) Walls that are smooth, finished with a washable high gloss or semi-gloss paint and reasonably free of exposed electrical conduits, and water and gas pipes.

(d) Benchtops that have a smooth, waterproof, chemically resistant covering that is easy to clean: Melamine, seamless vinyl, cast epoxy resin and stainless steel are recommended. Painted surfaces are not acceptable.

(e) Drainage shall be arranged so that it is isolated and so that other building areas cannot become contaminated if the drainage system becomes blocked.

(f) Secure storage facilities which may include refrigerators and freezers shall be provided for stocks of radionuclides. Shielding of the storage facility shall be provided if recommended by the RPA.

(g) The advice of the RSO shall be sought to determine if a fume cupboard is necessary for handling small quantities of non-volatile radionuclides that are of low radiotoxicity class (see AS 2243.4).

(h) Stainless steel sinks are required.

(i) A hand washbasin with automated action, or knee- or foot-operated taps, preferably immediately adjacent to the entrance doorway.

(j) A hand-held shower on a flexible hose and an eye wash facility.

3.7. Medium-Level Laboratories

A high degree of cleanliness is essential in medium-level laboratories, and finishes and. fittings shall be chosen to assist its achievement. In addition to meeting the requirements of 3.6 above, the laboratory shall comply with the following:

(a) The floor is strong enough to support the weight of any shielding while maintaining its smooth decontaminable continuous surface.

(b) Where welded PVC floor covering is used, a polyvinyl chloride content in excess of 76% by weight is to be used for ease of decontamination.

(c) The floor covering is coved up to and be sealed to walls and vertical surfaces to aid cleaning.

(d) Benches are to be strong enough to support the weight of any shielding likely to be used. The front and side edges of the benchtop is to be slightly raised and the back coved up to the wall or reagent shelf, so that the benchtop acts as a shallow tray to help contain spills.

(e) Joins between bench surfaces are to be designed and constructed so that they do not leak or trap contamination.

(f) A hand washbasin be provided and the taps shall be operated automatically, or be operated by knee or foot.

(g) Drainage systems shall be self contained and be appropriately labelled at accessible locations. Polyethylene and PVC pipes and fittings are recommended because they are resistant to most chemicals and are less likely than metal pipes to become internally contaminated.

(h) If glove boxes are to be used, each shall have its own exhaust air filter. Discharge of the exhaust air shall comply with the requirements of AS/NZS 2243.8.

(i) Laboratory ventilation requires careful design with outdoor fresh air quantities increasing as the quantity of radioactivity proposed for use increases. Table 9.1 provides a practical guide to the supply of outdoor air requirements for laboratories assuming a floor area of $10m^2$ per person and a ceiling height of 2.4 m.

NOTE: The RSO shall advise on recirculation of laboratory air within radioisotope laboratories. Fume cupboard exhaust air shall not be recirculated. Radioisotope laboratories shall be maintained at a negative pressure with respect to adjacent spaces. An alarm system that is automatically activated in the event of failure of the ventilation system shall be installed.

NOTE: The RSO shall determine whether overshoes and barriers are required.

NOTE: Laboratories of a medical or biological nature, where sterility of products also has to be maintained, will present special design difficulties. In such cases the RSO will need to resolve the different requirements of the radioisotope codes and standards, the

sterility standards for cleanrooms and the Australian Code of Good Manufacturing Practice for Therapeutic Goods. In addition, for product and operator protection, biological safety cabinets complying with AS 2252.2 may be required.

(j) Ceilings are to be smooth and decontaminable as for walls. Flush light fittings shall be used in preference to suspended fittings which will trap dust.

(k) Laboratories, in the upper part of the medium-level classification or above, shall have ceilings coved to the walls to aid cleaning.

(l) For medium-level laboratories in which higher levels of radioactivity are used, consideration shall be given to the provision of delay tanks for collection of the effluent before discharge to the sewer. The advice of the RPA, regulatory authority and waste water authority shall be sought when considering the need for, and design of, such a system.

(m) At least one fume cupboard in accordance with AS/NZS 2243.8 shall be provided. Appropriate exhaust air filters are desirable and provision shall be made to fit them at a later date even if they are not required in the first instance. Provision shall be made for exhaust air sampling. The base of the fume cupboard shall be capable of carrying 0.5 kg/cm^2 (0.5 MPa) averaged over the whole area of the base.

DOCUMENTATION

In accordance with NSW EPA Guideline 7, the following will be kept at the facility and a copy sent to the HS unit:

(a) Shielding Plans as per requirements of NSW EPA Guideline 7.

(b) Shielding CRE reports showing all details of assumptions made regarding workloads, energies, dimensions and occupancies etc.

(c) Shielding assessment reports by independent CRE or local physicist as per requirements of NSW EPA Guideline 7.

(d) Engineering drawings of facilities “as constructed” detailing any shielding including lead equivalence or HVL of each barrier as well as any pipes or ducting that may carry radioactive materials (waste or otherwise).

AUDIT

Every 2 years

REFERENCES

ARPANSA (2019) *"Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (RPS C-5)", ARPANSA, Yallambie*

ARPANSA (2008) “Safety guide for Radiation Protection in Diagnostic and Interventional Radiology (RPS 14.1)” *ARPANSA, Yallambie*

ARPANSA (2008) "Safety guide for Radiation Protection in Nuclear Medicine (RPS 14.2)" *ARPANSA, Yallambie*

ARPANSA (2008) "Safety guide for Radiation Protection in Radiotherapy (RPS 14.3)" *ARPANSA, Yallambie*

NSW EPA (2009) Radiation Guideline 7 – Radiation Shielding Design Assessment and Verification Requirements, EPA Sydney.

NSW EPA Radiation Guideline 6 (2020) – Compliance requirements for ionising radiation apparatus used in diagnostic imaging, Part 1 Mammography, Part 2 Radiography and BMD, Part 3 Dentistry, Part 4 Fluoroscopy, Part 5 Computed Tomography and Part 6 Veterinary Science, EPA Sydney

NCRP 2004, National Council on Radiation Protection and Measurements, Structural shielding design for medical x-ray imaging facilities, NCRP Report No. 147, Bethseda

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AS 2243.4 2018. Australian Standard 2243.4-2018: *Safety in laboratories – Ionizing radiations*, Standards Australia.

AS/NZS 2243.8:2014. Australian and New Zealand Standard 2243.8:2014: *Safety in laboratories – Fume cupboards*, Standards Australia.

AS/NZS 2982:2010. Australian and New Zealand Standard 2982:2010 *Laboratory design and construction - General requirements*, Standards Australia.

IAEA-TECDOC-1528 *Organization of a Radioisotope Based Molecular Biology Laboratory* December 2006. Vienna

IAEA-TECDOC-1367 *Practice specific model regulations: Radiation safety of non-medical irradiation facilities* August 2003. Vienna

NSW Government (2013) "Radiation Control Regulation"

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Oct., 2014	draft	William Bartolo, Bartolo Safety Management Service
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April, 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March, 2018	Revision 6	Melissa Musicka & William Bartolo, BSMS
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Oct., 2021	Revision 9	Melissa Musicka & William Bartolo, BSMS

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Safety with Sealed Sources
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S16
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REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Sealed Sources, Sealed Source Devices
SUMMARY *Brief summary of the contents of the document*	Safety and management of sealed sources and sealed source devices.

INDEX – Section 16

1. BACKGROUND

The University utilises sealed sources and sealed sources devices for a number of field research, scientific and teaching purposes. There are requirements contained in the legislation as well as in the Australian Standard and ARPANSA Codes of Practice. In particular some sealed sources need a licence and registration, some sealed sources require registration, and some are exempt. It is essential that sealed sources in each of these categories are identified so that proper steps can be taken to ensure maintenance of our legal requirements.

2. RESPONSIBILITIES

2.1. The University Radiation Management Licence Holder

The University via the Radiation Management Licence Holder RMLH alone is responsible for the purchase, possession and disposal of radiation apparatus and for ensuring that all relevant records are maintained.

The University via the RMLH will be responsible for ensuring that

(a) the maintenance, disposal or sale of sealed sources comply with the NSW Radiation Control Regulation 2013.

(b) copies of all maintenance and inspection reports undertaken on sealed sources (and sealed source devises), together with a copy of the registration certificate if relevant are kept in the area where the sealed source is used and copies are sent to HSW.

(c) annual and random inspections in regards to the management of these sealed sources are conducted by HSW.

Note: The records may be in hardcopy or electronic form.

Note: The records must be kept for at least 5 years and made available on request to an authorised officer of the EPA. They can only be disposed of after permission is granted from the State Director General.

2.2. The Radiation Management License Holder, Chief Investigators and Responsible Academics

Both the RML Holder responsible for the sealed source and chief investigators/responsible academics using these sources must ensure compliance with the following procedures relating to the storage, maintenance, disposal or sale of these sources. Normally, the process would occur jointly between these parties.

The CI and the RML Holder will ensure that the information that is to be contained in local and university inventory are the following details (NOTE: for many older sources and orphan sources the details may not be known, there was never a serial number or it has been worn off):

- Source Serial Number
- Isotope
- Date of calibration by supplier (or date of acceptance)
- Activity (in KBq or MBq)
- Storage location

3.0 SEALED SOURCES

A sealed source refers to radioactive material that is firmly bonded within metals or sealed in a capsule or similar container of adequate mechanical strength so that the active material cannot be dispersed into the environment under foreseeable conditions of use and wear. Typically, sealed sources are double encapsulated.

For more information on Neutron Gauges, (soil moisture gauges, etc) see Section 17.

Part of the legislative requirements for the registration of premises that store or use radioactive substances is the registration of sealed sources. The following is an extract of the current legislative requirements:

"**Act 2010**:

6 Restrictions on possession, use and sale etc of radioactive substances and certain radiation apparatus

(1) This section applies to the following:
(a) all radioactive substances,
(b) all ionising radiation apparatus,
(c) non-ionising radiation apparatus prescribed as apparatus to which this section applies.
(2) A person must not possess, use, sell or give away anything to which this section applies unless the person is the holder of a licence under this section and does so in compliance with any conditions to which the licence is subject.

7 Responsibilities of owners of sealed source devices and certain radiation apparatus

(1) This section applies to the following things:
(a) all sealed source devices,
(b) radiation apparatus that is prescribed as apparatus to which this section applies.
(2) The owner of anything to which this section applies is guilty of an offence unless it is registered under this section in the owner's name and any conditions to which that registration is subject are complied with.

8 Responsibilities of occupier of premises on which certain radioactive substances are kept or used

(1) The occupier of any premises on which a radioactive substance that is not contained in a sealed source device is kept or used is guilty of an offence unless the premises are registered under this section and any conditions to which that registration is subject are complied with.
(2) The occupier of premises registered under this section must not allow a person to use any radioactive substance that is not contained in a sealed source device and is kept on the premises unless the person is authorised to do so by a licence.

Regulations 2013

Part 2 Licensing and accreditation

8 Exemptions from radiation management licensing requirements for certain radioactive substances, ionising radiation apparatus and sealed source devices

A person is exempt from the requirement to hold a radiation management licence in relation to the following types of regulated material:

(a) radioactive substances specified in Part 2 of Schedule 3,
(b) ionising radiation apparatus specified in Part 4 of Schedule 3,
(c) sealed source devices specified in Part 5 of Schedule 3.

9 Exemptions from radiation user licensing requirements for certain radioactive substances and ionising radiation apparatus

A person is exempt from the requirement to hold a radiation user licence in relation to the following types of regulated material:

(a) radioactive substances specified in Part 1 or 2 of Schedule 3,
(b) ionising radiation apparatus specified in Part 3 or 4 of Schedule 3.

Schedule 3 Exemptions from licensing

(Clauses 8, 9 and 46)

Part 1 Exemptions from radiation user licensing requirements for certain radioactive substances

1 Sealed source devices used for radiation gauging installed in fixed positions
2 Self-shielded irradiators (that is, gamma irradiators in which the radioactive substance is completely enclosed in a dry container constructed of solid material that shields the radioactive substance)

Part 2 Exemptions from radiation management and radiation user licensing requirements for certain radioactive substances

1 Radioactive substances in luminous dials on any devices, including on clocks and watches
2 Gaseous tritium in luminous devices, including in self luminous "EXIT" signs
3 Radioactive substances used in nuclear medicine for checking gamma cameras and dose calibrators and having a level of activity of less than 40 megabecquerels
4 Radioactive substances used as laboratory reference sources and having a level of activity of less than 40 megabecquerels
5 Radioactive substances for demonstration, teaching or training having a level of activity of less than 40 megabecquerels
6 Uranium metal of natural isotopic composition, or depleted in uranium 235, which is used as radiation shielding in transport packages for radioactive substances or is used in any other manner
7 Radioactive substances in gas chromatography detectors
8 Radioactive substances used as static eliminators and having a level of activity of less than 40 megabecquerels
9 Radioactive ores that are at any place to which the Coal Mine Health and Safety Act 2002 applies
10 Radioactive ores that are at any place to which the Mine Health and Safety Act 2004 applies
11 Radioactive ores that are at any place where activities that are regulated under the Petroleum (Offshore) Act 1982 are carried out
12 Radioactive ores that are at any place where activities that are regulated under the Petroleum (Onshore) Act 1991 are carried out
13 Americium 241 in industrial smoke detectors that do not contain any other radioactive substance

Part 5

(Repealed)

Since sealed sources not contained in a sealed source device are not excluded from registration, except as reference, teaching and training sources below 40 MBq, then all sealed sources not contained in a registered device must be inventoried and listed under the Radiation Management License.

In addition, any sealed sources that are deemed to be classed as a Security Enhanced Source must comply with the security requirements of the Legislation and the ARPANSA RPS11 Code in terms of security, storage and management. ***It is the responsibility of the chief investigator to determine the cost of any additional security required before purchase***

The following table gives the threshold levels for some of the sealed sources of concern, above which Security as per the legislation and necessitating a Security Plan is required:

Threshold activities for sealed radioactive sources

Radionuclide	Activity (GBq)	Element
Am-241	60	Americium
Am-241/Be	60	Americium/Beryllium
Au-198	200	Gold
Cd-109	20,000	Cadmium
Cf-252	20	Californium
Cm-244	50	Curium
Co-57	700	Cobalt
Co-60	30	Cobalt
Cs-137	100	Caesium
Fe-55	800,000	Iron
Gd-153	1,000	Gadolinium
Ge-68	700	Germanium
Ir-192	80	Iridium
Ni-63	60,000	Nickel
Pd-103	90,000	Palladium
Pm-147	40,000	Promethium
Po-210	60	Polonium
Pu-238	60	Plutonium
Pu-239/Be	60	Plutonium/Beryllium
Ra-226	40	Radium
Ru-106 (Rh-106)	300	Ruthenium (Rhodium)
Se-75	200	Selenium
Sr-90 (Y-90)	1,000	Strontium (Yttrium)
Tl-204	20,000	Thallium
Tm-170	20,000	Thulium
Yb-169	300	Ytterbium

For Security Assessment and requirements please contact University of Newcastle HSW unit.

3.1 Requirements of Australian Standard 2243.4

AS2443.4 details safety considerations when working with sealed sources. These include:

(a) Sealed sources must be handled remotely (e.g. by using tongs or forceps) and for the minimum possible time.

(b) Locating shielding as close as practicable to the source of radiation. Precautions should be taken to protect laboratory workers and persons in adjacent areas from direct and scattered radiation.

(c) Every sealed source should be labelled with, and a record kept of the following:

i) the serial number or identification code.

ii) the nature of the source, its date of receipt, and its activity upon receipt.

iii) A record will be kept with the source and by HSW detailing where it is being stored, where it is being used and where to and when it is relocated.

iv) In addition HSW will keep a record of its date and details of disposal.

(d) When not in use, store sealed sources in secure and adequately shielded containment, which is labelled with the international radiation symbol and other relevant information.

(e) Where a source could potentially release a radioactive gas, the storage area must be adequately ventilated. Exhaust ventilation should be run for an adequate time before entering the area.

Sealed sources may be used in either an enclosed or open installation.

3.2 Safety Guidelines for Sealed Source Enclosed Installations

Permanent enclosures for any source of radiation and the materials being irradiated should be designed so that:

- No person can be within the enclosure during an irradiation.
- Interlocks prevent persons from entering the enclosure during an irradiation.
- Any person accidentally shut in an enclosure be able to leave by a suitable exit or be able to immediately enter an adequately shielded refuge.
- An irradiation is capable of being prevented or quickly interrupted from within a large enclosure. It should not be capable of being reset from outside the enclosure.
- Persons outside the enclosure are adequately protected.
- During operation, the dose rate at any accessible outside surface of any large enclosure should not, in any one hour, exceed 10*u*Sv. If non-radiation workers have access to the outside area, the dose should not exceed 0.5*u*Sv.
- When not in use, sealed sources should be placed into a secure and shielded housing. This will be carried out by remote control.

- Fail-safe interlocks and control systems shall be provided on all enclosed installations. If electrically operated, the system shall be rendered inoperative or non-hazardous in the event of loss of electrical power.

3.3 Safety Guidelines for Sealed Source Open Installations

In an open installation, the source of ionizing radiation and the materials being irradiated should be confined as far as possible within a specific area. The area should be outlined by suitable barriers, appropriate warning signs displayed, and follow the requirements of an enclosed installation as detailed above, so that:

- only authorised persons have access to the area.
- persons outside the area are not exposed to the source of radiation.
- authorised persons enter the area for the minimum time needed to make essential adjustments to the equipment.
- if possible, the apparatus be capable of adjustment by remote handling methods.

There are several NHMRC Documents that deal with sealed sources for medical applications that would be of use for developing safety procedures. Please note that some of these have been revised and are now listed as ARPANSA RPS documents and some are still in the process of being revised and replaced by the ARPANSA Radiation Protection Series.

3.4 Purchase of Sealed Sources

Before purchase, the chief investigator must ensure security costs and if a sealed source purchase is being contemplated please ensure the following:

(a) The purchase has as part of the contract return to the supplier when unwanted or decayed.

(b) If not possible or economic to return to supplier that there is a disposal pathway.

(c) That funds are allocated for any disposal of sealed sources (this can be a very expensive exercise).

(d) Please refer to RMP Section 18 for further guidance

3.5 Sealed Sources Lacking Proper Identification Or Lacking Disposal Pathway

Any person who detects or has a sealed source lacking proper identification or lacking disposal pathway at the time of purchase (e.g. purchases or acquisitions pre 2010) that needs to be disposed of should contact HSW.

In some cases the sealed source may still be highly radioactive. If this is the case, the following alternatives should be considered:

(a) return to the supplier;

(b) transfer to another user; or

(c) store in a suitable facility.

In all cases, HSW, the RSO and the Statutory Authority (EPA) should be notified of the decision to be taken.

3.6 Storage of Sealed Sources

When not in use the sealed source must be replaced into its shielded container (if it has one) and returned to its approved, designated storage facility that is kept under lock and key. There must be an inventory of all sources for this location and must be maintained on a regular basis.

As far as practicable and taking into account the ALARA principle, sealed sources should not be stored near regularly occupied or frequented areas. The dose rate at the surface of the storage facility is to be less than 5 µSv/hr if only occupationally exposed persons have access, or less than 0.5µSv/hr if accessible by the general public. Furthermore, sealed sources should not be stored in the same storage area as dangerous goods of the following Dangerous Goods Classes:

1 Explosives
2.1 Flammable gas
3 Flammable liquid
4.1 Flammable solid
4.2 Spontaneously combustible
4.3 Dangerous when wet
5.1 Oxidising agent
5.2 Organic peroxide
8 Corrosive

The name and contact details of University of Newcastle HSW, or other relevant person, should be placed on the store in a conspicuous location.

3.7 Sealed Source Maintenance

It is expected that each sealed source is checked regularly by the person responsible for a approved designated storage area or their approved agent, either quarterly, six monthly or yearly to ensure that the sealing material maintains its integrity and that it is not degrading. The check involves examining for faults such as cracks or chips and conducting a surface ‘Wipe Test’ to ensure that the radioactive isotope is not “leaking”, by separating from the sealing compound and becoming a free agent. The ‘Wipe Test’ should be left to an expert familiar with sealed sources or equipment containing these sources.

Comprehensive records must be kept for each sealed source, including results of wipe tests (Contamination Survey), visual inspections etc. The person responsible must send the results of such checks to HSW at least annually, or immediately if the integrity of the source is determined to have failed.

3.8 Disposal of Sealed Sources

Refer to Section RMP-S18, and also 3.4 and 3.5 above.

For ionising equipment that contains radioactive source(s), as part of the purchase agreement/contract there should (shall) be a clause in regards to the return of the source(s) to the supplier at the end of the working life of either the source or the equipment whichever comes first.

DOCUMENTATION

Records of use,
Records of storage,
Record of inspection and maintenance of the source(s).

AUDIT

Every 2 years

REFERENCES

None

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Nov., 2014	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
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March, 2018	Revision 6	William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Ms Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Ms Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Safety with Neutron Gauges
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S17
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Soil moisture, neutron, soil density, neutron safety
SUMMARY *Brief summary of the contents of the document*	The basics from the mandated code of practice for the safe use of neutron gauge equipment.

INDEX – Section 17

1. BACKGROUND

Neutron gauges (soil moisture/density measuring equipment) are used for field research, scientific research and teaching purposes. These portable devices have radioactive sources. Their portability means that they are more readily lost or stolen and therefore the Commonwealth of Australia has special acts and guidelines to control these devices. To ensure that the various Acts are abided by, a Code of practice has been developed by ARPANSA Code of practice RPS 5 (*Code of Practice and Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*) and compliance with this code is a condition of the University Radiation Management License

Note: due to the nature of the legislation, researchers purchasing or acquiring such a device should plan for a six month lag period between submission of the proposal to being able to purchase and use the equipment.

2. RESPONSIBILITIES

2.1. The University/Radiation Management Licence Holder

The University via the Radiation Management Licence Holder alone is responsible for the purchase, acquisition, possession storage and disposal of radiation apparatus (neutron gauges) and for ensuring that relevant records are maintained.

The University via the Radiation Management Licence Holder will be responsible for ensuring that

(a) the purchase, storage, repair, maintenance, disposal or sale of radiation apparatus comply with the NSW Radiation Control Regulation 2013.
(b) copies of all maintenance and inspection reports undertaken on radiation apparatus, together with a copy of the registration certificate are kept with the apparatus and copies are sent to HSW.
(c) annual and random inspections in regards to the management of this apparatus are conducted by HSW.

Note: The records may be in hardcopy or electronic form.

Note: The records must be kept for at least 5 years and made available on request to an authorised officer of the EPA. They can only be disposed of after permission is granted from the State Director General.

2.2. The Radiation Management License Holder, Chief Investigator and Responsible Academic

Both the RML Holder responsible for the equipment and chief investigators/responsible academics using the equipment must ensure compliance with the following procedures relating to the purchase or acquisition, storage, repair, maintenance, disposal or sale of radiation apparatus. In terms of purchase or acquisition please refer to Section 4 of the RMP. Normally, the processes would occur jointly between these parties.

The Radiation Management Licence holder has the recommendation to notify the appropriate fire authority and police of the storage locations of each portable density/moisture gauge under their control if and when required by the authority. This maybe required for storage at permanent locations and is of particular importance when the gauge or gauges are stored at semi-permanent locations (as may be the case in field studies). The RML holder is required to organise the safety training of personnel, by an accredited trainer, on the use of the gauge, and should be done at the initial induction of these personnel. Refresher training should be undertaken at no more than 5 year intervals however, training may need to be more frequent where there have been changes to legislation or other safety requirements that are relevant to those personnel.

NOTE: NSW legislation requires that users are licensed (or students are exempted and under supervision during use of the gauge) and are suitably trained by an EPA approved trainer.

Every use of or project using ionizing radiation by a student, or staff member, of the University (please note: they must hold either an appropriate licence or an exemption) at any site, or the use by other persons at a University premise, requires prior project approval of the CRTC. Reporting details are included on this form. The ARPANSA document suggests that the review period is annual.

No testing will be done unless all relevant authorisations (licenses, permission from the land owner to access land for testing, etc) ***are to be obtained in writing before*** the testing is to be conducted;

All users of soil density and moisture gauges shall:

(a) hold a current radiation user's licence issued by the EPA (NSW), or hold a written exemption issued by an appropriately licensed person;

(b) acquaint themselves with and obey all notices and all instructions issued to them for the safe use of these devices;

(c) must only use the device in accordance with CRTC approved project details;

(d) wear an appropriate personal monitoring device at all times when these instruments are in use;

(e) not interfere with, remove, alter, damage or render ineffective any soil density and moisture gauge or radiation protective equipment provided;

(f) comply with any method or working procedure adopted to reduce radiation exposure;

(g) immediately report to the HSW and the CI any difficulties with working procedures or defects in equipment which may have caused or are likely to cause a radiation hazard;

(h) complete moisture gauge usage log records whenever the gauges are used, and store these log records together in a folder (close to the stored gauges) so that they are available for future radiation audits.

(i) The User or Chief Investigator must maintain records of calibration and maintenance with these being kept near the gauge; and

(j) Before using the gauge, the user must confirm that calibration and maintenance are current.

3.0 GUIDELINES FOR THE SAFE USE OF SOIL MOISTURE GAUGES

Only the Radiation Management Licence Holder (or their delegate) can purchase and possess such sealed source items. Therefore the requirement is that all ownership and use of such items is approved through the set University procedures. An important part of these procedures is having a path of disposal organised before the purchase of these items.
The following Standard Operating Procedures (SOPs) are in addition to any other requirements that are already listed in this Radiation Management Plan.

The following is based on the relevant sections of *Safety Guide: Portable Density/Moisture Gauges Containing Radioactive Sources, Radiation Protection Series No. 5 (May 2004)*.

Every use of or project using ionizing radiation by a student, or staff member, of the University at any site, or the use by other persons at a University premise, requires prior project approval of the CRTC. The persons involved must hold either an appropriate licence or an exemption. The ARPANSA document suggests that the review period is annual.

3.1 Working Rules based on ARPANSA RPS 5

(a) All operators/users of the gauge are to be registered with HSW and are to be personally monitored with a Neutron Type TLD and possibly a standard TLD (both these dosimeters are to be a regulatory authority approved service): the TLD is to be worn at either the belt level or on the chest;

(b) The expected radiation levels around each portable density/moisture gauge are to be such that the dose received by the operator person is kept at less than 60% of the annual dose limit for the occupationally exposed person, and the dose rate 1 metre from the gauge should be no greater than the following;

(c)When the source(s) is/are in the shielded position, the radiation levels from the gauge must not result in an ambient dose equivalent rate or directional dose equivalent rate, as appropriate, exceeding:

- 250 µSv/hr at any point 0.05m from the gauge surface; and
- 10 µSv/hr at any point 1m from the gauge surface.

(d) The gauge must be used as per the instruction manual (or the supplier/manufacturer's recommendations), safe methods for the use of the gauge are to be employed at all times. No more than 3 people are to involved in the direct use of the gauge at any time, all other persons are to be at least 3 metres from the instrument;

(e) From (b) above the method(s) for conducting the survey, any other safety tests are to be documented.

(f) When not in use the gauge is to be housed in a secure and shielded storage facility that has been approved by HSW and this facility shall have the appropriate warning signs, and have a dose rate of less than 5 µSv/hr at the surface of the facility;

(g) All operators/users of the gauge are to be personally monitored with a Neutron Type TLD and possibly a standard TLD:
i). The TLD is to be worn at the belt level.
ii). the control monitor is not to be kept near the gauge at any time.

(h) When soil testing is being conducted, no-one other than those directly operating the unit will be allowed within 3m of the site. The use of appropriate signs such as the example in Annex A are to be displayed at the four compass points of the testing site. An individual from the testing team will be appointed as the site supervisor, so as to maintain safe distance, the appropriate use of signs and equipment as well as all safety records;

(i) All relevant authorisations (licences, permission to access land for testing, etc.) are to be obtained in writing before the testing is to be conducted.

(j) Emergency Procedures approved by HSW and an emergency kit kept near (but not with) the gauge at all times; The **Emergency kit** consists of:

i). Portable neutron and radiation monitor/instrument,
ii). cones/poles and tape to demark the crisis area,
iii). communication device (mobile phone, radio, etc), and
iv). appropriate tools and utensils to deal with most envisaged situations.

(k) During transport (see part 3.6 below), and when in the field but not being used, the gauge is to be transported in its packaging as far from the driver and passengers as possible (preferably in the boot of the vehicle). The unit is to be secured within the vehicle to prevent theft and loss, and the source(s) kept locked in the shielded position when the unit is not in use. The unit is not to be left unsecured or uncontrolled at any time.

(l) The integrity of the gauge is to be maintained by regular servicing by an authorised service agent/company. This will also include calibration of the source on an annual or bi-annual time frame. Records of all services and calibrations are to be maintained.

(m) Unless in use, the gauge is to be kept in its transport packaging.

i). For details of transport see 3.3
ii). For storage details see 3.2;

(n) The emergency contacts are:

i). **Health and Safety, Ph: 02 4921 6846**.
ii). **Security, Ph 4921 5888**
iii). **The Radiation Control Branch, EPA, Ph: 02 9995 5000**.

3.2 Storage of Gauges

When not in use, the gauge should be locked in its transport case.

As far as practicable and taking into account the ALARA principle, portable density/soil moisture gauges should not be stored near regularly occupied or frequented areas. The dose rate at the surface of the storage facility is to be less than 5 µSv/hr if only occupationally exposed persons have access, or less than 0.5µSv/hr if accessible by the general public. Furthermore, portable density/soil moisture gauges should not be stored in the same storage area as dangerous goods of the following Dangerous Goods Classes:

1 Explosives
2.1 Flammable gas
3 Flammable liquid
4.1 Flammable solid
4.2 Spontaneously combustible
4.3 Dangerous when wet
5.1 Oxidising agent
5.2 Organic peroxide
8 Corrosive

The name and contact details University of Newcastle Health and Safety, or other relevant person, should be placed on the store in a conspicuous location.

3.3 Transport of Gauges

(a) While in a vehicle, the case must not be visible to a passer-by.

(b) The container cannot be transported in the passenger compartment

(c) When transported on roads, the gauge shall be locked in its original carry case/transport container;

(d) The container shall be locked

(e) The container shall be fixed in location within the vehicle with the shutter mechanism facing away from the vehicle occupants or facing downwards;

(f) The unit must be secured in such a fashion that theft is very difficult and loss from the vehicle during transport is not possible.

Gauges will not be transported with incompatible classes of dangerous goods unless written approval has been obtained from HSW.

The gauge cannot be transported across State borders without prior written approval from HSW and the relevant regulatory authorities.

4.0 DOCUMENTATION

Storage Log Book, that is a record of the time the gauge is in the storage facility;

User/Use Log Book, that is a record of all use or display of the unit, when, where and by whom;

Service, Repair and Calibration Log Book

Instrument Accident/Incident Records

5.0 AUDIT

Every 2 years

6.0 REFERENCES

ARPANSA. CODE OF PRACTICE & SAFETY GUIDE: Portable Density/Moisture Gauges Containing Radioactive Sources (2004) Radiation Protection Series Publication No. 5

7.0 REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Nov., 2014	draft	William Bartolo, Bartolo Safety Management Service
Feb, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March, 2018	Revision 6	Melissa Musicka & William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Melissa Musicka & William Bartolo

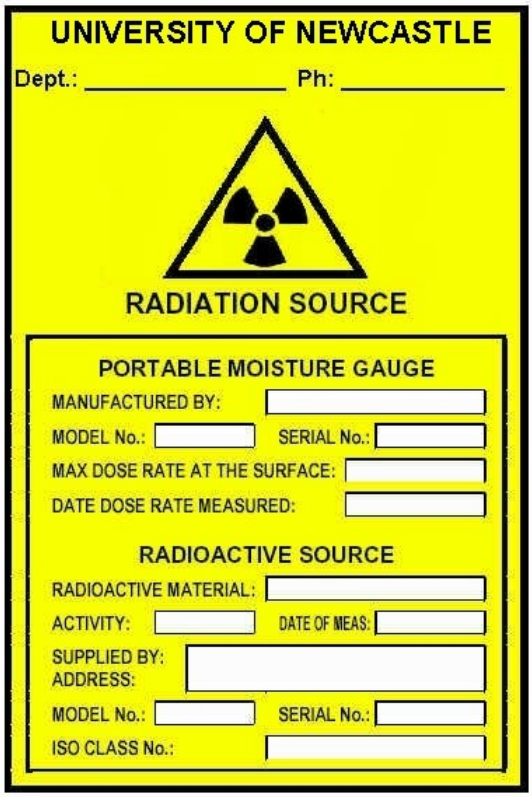
Appendix 17.1: Radiation warning signs and labels

Radiation warning signs and labels, must conform to AS 1319 *Safety signs for the occupational environment*, and AS 2342 *Development, testing and implementation of information and safety symbols and symbolic signs*. Examples of suitable warning signs and labels are given below.

Colours for radiation warning signs and labels
Background: yellow
Marking and trefoil: black

EXAMPLE OF A SUITABLE WARNING SIGN FOR POSTING IN THE AREA ADJACENT TO PORTABLE DENSITY/SOIL MOISTURE GAUGE WHEN IN USE (55 x 22cm min size)

EXAMPLE OF A SUITABLE WARNING LABEL FOR ATTACHMENT TO A PORTABLE DENSITY/SOIL MOISTURE GAUGE CONTAINING A RADIOACTIVE SOURCE



The information included on this label should reflect the gauge's use (e.g. Density only, moisture only (version depicted above) or combination) and its total radioactive contents (e.g. caesium only, ^{241}Am/Be only or both).
(NOTE: the lower part of this label may be unpainted metal with black lettering).

EXAMPLE OF A SUITABLE WARNING LABEL FOR DISPLAY ON A RADIATION STORE

INTERNAL ONLY

RADIATION MANAGEMENT PLAN
COVER SHEET

NAME OF DOCUMENT	Storage and Disposal of Radioactive Waste
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S18
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, radioactivity, radioactive waste
SUMMARY *Brief summary of the contents of the document*	Procedures for the safe storage and disposal of radioactive waste

INDEX – Section 18

1. BACKGROUND

This document describes appropriate methods for the storage and eventual disposal of waste radioactive material. Legislation requires that the Radiation Management License Holder is the responsible person for this waste from the time of acquisition, and this responsibility cannot be delegated. However, the Chief Investigator/Responsible Academic must ensure that the correct procedures are followed for storage and disposal of radioactive waste.

The International Commission on Radiological Protection (ICRP) has three waste concepts as follows:

- Delay and decay (*applicable to radionuclides with short half-lives*)
- Concentrate and contain, (*applicable to all radioactive waste*)
- Dilute and disperse (*possible, but discouraged and without great care could be in breach of the Regulatory Guidelines. Regulatory authorities may apply a limit of 1 Bq/L (above background) to the sewerage system, above which double delay tanks with other restrictions may be required.)*

NOTE:

Half Life	Radionuclide
Five days or less:	Na-24, K-42, Cu-64, Tc-99m, Mo-99
Five days to two montHSW:	P-32, Cr-51, Fe-59, 1-125, 1-131, Cs-131
Two montHSW to one year:	S-35, Ca-45, Sc-46, Sn-113
Greater than one year:	H-3, C-14, Na-22, Cl-36, Co-57, Co-60, Cs-137

Note: The EPA's ***Waste Classification Guidelines Part 3: Waste Containing Radioactive Material:*** *November 2014*, *(all procedures and requirements contained within)* must be adopted into the waste procedures. This document is enacted through the *Protection of the Environment Operations Act 1997.*

Note:
Radioactive Waste is classified as the following:

- Liquid or non-liquid wastes with a specific activity greater than 100 becquerels per gram and consisting of, or containing more than, the prescribed activity (see Appendix 18.1 of this Section) of a radioactive element in Schedule 1 of the Radiation Control Regulation 2013, whether natural or artificial, must be classified as ***hazardous* wastes**.
- For liquid or non-liquid wastes with a specific activity of 100 becquerels per gram or less and/or consisting of, or containing, the prescribed activity or less of a radioactive element in Schedule 1 of the Radiation Control Regulation 2013, whether natural or artificial, the *total activity ratio* and *specific activity ratio* must be calculated according to the mathematical expressions below:

Total activity ratio is calculated using the expression:

$$\text{Total activity ratio} = (A1 \times 10^{-3}) + (A2 \times 10^{-4}) + (A3 \times 10^{-5}) + (A4 \times 10^{-6})$$

where A1 to A4 are the total activity of Group 1 to Group 4 radionuclides, as set out in Column 1 of Schedule 1 of the Radiation Control Regulation 2003.

Specific activity ratio is calculated using the expression:

$$\text{Specific activity ratio} = SA1 + (SA2 \times 10^{-1}) + (SA3 \times 10^{-2}) + (SA4 \times 10^{-3})$$

where SA1 to SA4 are the specific activity (of the material) of Group 1 to Group 4 radionuclides, as set out in Column 1 of Schedule 1 of the Radiation Control Regulation 2003.

Definition
'*Specific activity*' is defined in the *Code of Practice for the Safe Transport of Radioactive Materials* (Australian Radiation Protection and Nuclear Safety Agency 2008) as follows:

- 'Specific activity of a radionuclide shall mean the activity per unit mass of that nuclide.
- The specific activity of a material shall mean the activity per unit mass of the material in which the radionuclides are essentially uniformly distributed.'

Non-liquid wastes must be classified as *restricted solid waste* **unless**:

- other characteristics of the waste mean that it must be classified as *hazardous waste* (for example, it may be pre-classified as *hazardous waste* in accordance with Step 3 of Part 1 of the *Waste Classification Guidelines* [EPA 2014]; or
- it contains chemical contaminants that will lead to its assessment as *hazardous waste* (see Step 5 of Part 1 of the *Waste Classification Guidelines*.

Where the *specific activity ratio* and *total activity ratio* are equal to or less than one, the waste must be classified according to its other characteristics in line with Part 1 of the *Waste Classification Guidelines*.

Definition:
Restricted solid waste
Currently, no wastes have been pre-classified by the EPA as 'restricted solid waste'. Restricted solid waste therefore only includes wastes assessed and classified as such in accordance with the procedures in Step 5 of this guide.

However the EPA may classify waste as restricted solid waste from time to time by a notice published in the *NSW Government Gazette*. All currently gazetted restricted wastes will be listed on EPA's website at www.environment.nsw.gov.au/waste/wastetypes.htm.

According to the Radiation Control Act 1990 and Regulations 1993 (and all subsequent amendments) for the Radiation Management License Holder to dispose of radioactive

waste, they must have received written authority from the Director-General To date, the D-G has not had any need to give such authority to an institute and therefore to be compliant, the radioactive waste must be stored by the license holder.

2. RESPONSIBILITIES

2.1. Generator Of Radioactive Waste

Generator Of Radioactive Waste (Researcher, Student, Laboratory Personnel etc) Must:

- for a particular series of experiments, collect and store the radioactive waste such that has minimum and proper containment. The waste must be collected after each experiment or procedure that generates waste (section 4.1);
- label waste containers with a University Rad Waste Label (see Appendix 18.2 of this Section) that has been filled in with the information required.
- Complete all required documentation and local records (the same details as in on the waste label);
- When the waste container is full, or it is appropriate time for the waste to be processed by the University, complete the waste form and contact HSW;
- Complete all necessary disposal and transfer forms.

Note: Disposal will then be the responsibility of the Radiation Management License Holder who will delegate the management to HSW (and the RSO) for final management and disposal (if possible).

2.2. Chief Investigators/Responsible Academics

Chief Investigators/Responsible Academics that are responsible for projects and procedures that generate radioactive waste must:

- inform and obtain permission from the radiation safety officer or their delegate before storing or disposing of radioactive waste.
- ensure compliance with current legislation regarding storage and disposal of radioactive waste
- ensure that others involved with the project or procedure comply with the current legislation regarding storage and disposal of radioactive waste
- ensure that themselves or others who generate radioactive waste record the nature and storage of such radioactive waste in the logbook provided in the facility or storage area
- ensure that all dealings with radioactive waste storage or procedures are kept in a written form (could be electronic) and the documents stored for at least 5 years and destroyed only if permission is gained from the Director-General of the EPA.
- ensure that personnel involved with the project or procedure are properly trained and wear personal protective equipment (PPE), appropriate to the hazard

2.3. Central Radiation Waste Store Manager

The person responsible for the central store will ensure:

- that the storage area or facility complies with legislation; and
- a logbook of stored radiation material is available and kept in the storage area or facility

2.4. Radiation Management Licence Holder

Radiation Management Licence Holder must ensure that:

- all radioactive waste is stored or disposed of in accordance with the current legislation
- all dealings with radioactive waste storage or procedures are kept in a written form (could be electronic) and documents stored for at least 5 years and destroyed only if permission is gained from the Director-General of the EPA.
- a store or storage area for radioactive sources within the premises is constructed of durable materials, is lockable and secure.

NOTE: Requirements for an approved radiation waste store or storage area
From the EPA Radiation Guideline 7 Radiation shielding design assessment and verification requirements, the shielding plan must ensure that any member of the general public occupying the adjoining areas (including above and below) is not exposed to more than the general public design constraint of 20 µSv per week.

All storage facilities must meet the appropriate requirements of the legislation and ARPANSA RPS11. Sealed sources and premises that are registered under the Radiation Management Licence, must meet the conditions of their registration, in addition to the requirements of this procedure.

2.5. Radiation Safety Officer

The Radiation Safety Officer (acting as the delegate of the RML holder) must:

- ensure that logbook, labels and records of transfer documentation are correct;
- ensure that the package(s) are verified in terms of dose rate (activity and specific activity)
- sign off that the records pertaining to all of the radioactive waste are correct and up-to-date.

PROCEDURE

2.6. Storage Procedures (Identification, Location, Record Keeping, etc.)

2.6.1. Radioactive waste must:

(a) have appropriately shielded and labelled waste containers dedicated to the project

(b) NOT be mixed with waste from other projects

(c) Be contained in the appropriate waste bag or bags (that is double bagged; seek advice from HSW)

(d) be stored in appropriately shielded and labelled containers in an area approved for storage of radioactive material

(e) be clearly identified with the University Radioactive Waste Label (see Appendix 18.2 of this Section)

(f) NOT be stored with explosive, combustible or corrosive material

2.6.2. Sharps e.g. needles or needles with syringes attached which may be contaminated with radioactivity must be stored in a trefoil labelled sharps container. The sharps containers must not be overfilled and labelled with the University Rad Waste Label.

2.6.3. If the radioactive waste includes another type of hazardous waste e.g. biological waste, then **Mixed Waste** storage must comply with the conditions for radioactive waste storage and for the storage conditions for the other hazardous waste.

Note: **Mixed waste** is defined as a waste that is both radioactive and contains a non- radioactive contaminant that is itself considered a hazardous material, such as biological waste. Such wastes are subject to regulation for both hazards, which adds to their complexity when dealing with them. For this reason, mixed wastes should be avoided, but with research and teaching this is often unavoidable.

2.6.4. ***Scintillation Fluids*** **-** Used scintillation vials are not to be decanted of their contents before disposal. The used vials should be stored in a plastic pail of no more than 15 litres. This is to reduce the risk of manual handling problems and to minimise the time required dealing with used scintillation vials. The pail should be labelled as per 4.1.1 and have a lid that will seal the pail. DO NOT OVERFILL these pails: the lid must properly close and seal the container.

Once the pail is filled, the chief investigator, etc. of the project will organize for the consultant RSO to measure the activity and determine the disposal or storage procedure to be followed.

2.7. Waste Material Destined For The University Radioactive Store (Conditioning/packaging and storage of radioactive waste for long term storage)

The radiation management licence holder and/or his/her delegate will adhere to the principles associated with Annex E of the Safety Guide entitled Predisposal Management of Radioactive Wastes (RPS 16) for management of medical and laboratory radioactive waste (Appendix 18.3 of this section). This will be done in consultation with the RSO.

2.8. Disposal Procedures

User license personnel shall take the following steps once a waste container is full or the project completed (whichever is sooner):

(a) contact HSW to approve or confirm procedures for waste storage or disposal.

(b) The generator of the waste will complete all necessary disposal and transfer forms.

(c) Once the assessment as per the guidance in the Background Section is completed for all radioactive waste then refer to Part 1 of the EPA Guidelines for the documentation and procedures required for notification and disposal.

NOTE: the classification of the waste type (e.g. hazardous, industrial and non-radioactive) must be clearly indicated in the documentation.

NOTE: The type of waste generated can take the following forms:

- airborne wastes such as radioactive gases, vapours, or particulate material;
- liquid radioactive wastes: These include animal excreta and aqueous solutions of radionuclides or suspensions of radioactive material in water or water-miscible liquid(s). Another category of liquid wastes is that of organic solvents which, because they are flammable or toxic, usually require special methods of disposal such as incineration in an approved incinerator (currently no Environmental Permit or Licence has been issued to a waste facility for such purposes);
- solid wastes include liquid in solid containers, sealed sources and rubbish. Sealed sources are generally in the form in which they were originally purchased; whilst
- rubbish includes contaminated packing materials, laboratory glassware, pipette tips, plastic vials and trays, paper tissues, used syringes, etc; and
- radioactive animal carcasses (from research activities) need special consideration. Carcasses of small animals such as mice and rats, and excised organs of larger animals, will need to be kept frozen until such time as the carcass and the associated radioactive contamination is deemed acceptable for disposal. The nature and quantity of radioactivity involved should be taken into account in selecting the appropriate option.

Larger animals contaminated with radioactive materials are definitely a major problem. Please contact HSW and the University CRTC while in the planning stages for this work.

(d) University of Newcastle HSW in conjunction with the University of Newcastle RSO will determine the action and the transfer to the University Central Radioactive Waste Store.

2.9. Minimisation, Segregation and Disposal

The effective management of low and intermediate level waste depends on knowledge of the waste characteristics and the contained radioactivity. The volume of radioactive waste should be kept to a minimum and should be categorised according to its method of disposal at as early a stage as possible. Non-radioactive waste and very low level waste (that is, below the exemption levels set by the regulatory authority) should be kept separate from waste that needs to be disposed of as radioactive waste. This waste should be monitored by the HSW/RSO to confirm its status before being removed from a controlled area. It is useful to segregate radioactive waste on the basis of half-life in order to facilitate appropriate storage and disposal. For example, waste can be segregated into short-lived and long-lived radionuclide bins. The bins should be well shielded and the content disposed of when the activity drops to a sufficiently low level such that it is indistinguishable from background when measured with an area radiation monitor. Care must be taken to remove or deface any indications that the disposed waste is radioactive.

2.10. Sealed Source Disposal

Sealed source disposal is difficult. There should have been an agreement as part of the purchase contract that at end of working life the source was to be returned to the supplier for disposal or re-use. See the relevant sections of RMP-S16.

Generally the following are to be applied:

- Return to supplier
- Store indefinitely until the source is deemed to be non radioactive
- Dispose if deemed to no longer radioactive.

The guidelines for disposal under the POEO legislation are mandated. Please contact HSW and/or the RPA for further advice.

Sources cannot be transferred to another licensee unless the source is identified a serial number or identification code, plus the identity of the radionuclide and its activity and preferably a calibration date.

Once a sealed source has reached a point where it can be disposed, all identifying marks and signs need to be removed and the source checked by the RPA to ensure compliance with relevant legislation.

DOCUMENTATION

Registers of radioactive substances
Waste storage and disposal records

AUDIT

Every 2 years

REFERENCES

None

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Nov., 2014	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	Ms D Edmunds, and Mr W Bartolo
April, 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March, 2018	Revision 6	Melissa Musicka and William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Melissa Musicka and William Bartolo
Nov., 2021	Revision 9	Melissa Musicka and William Bartolo

Appendix 18.1

Prescribed activity of a radioactive substance

Column 1					Column 2
Group 1					
Ac227	Am241	Am243	Cf249	Cf249	40 kilo-becquerels
Cf250	Cf252	Cm242	Cm243	Cm244	
Cm245	Cm246	Np237	Pa231	Pb210	
Po210	Pu238	Pu239	Pu240	Pu241	
Pu242	Ra223	Ra223	Ra226	Ra228	
Th227	Th228	Th230	U230	U232	
U233	U234				
Any alpha emitting radionuclide that is not included in any other Group in this Schedule					
Group 2					
Ac228	Ag110m	At211	Ba140	Bi207	400 kilo-becquerels
Bi210	Bk249	Ca45	Cd115m	Ce144	
Cl36	Co56	Co60	Cs134	Cs137	
Eu152	Eu154	Ge68	Hf181	I124	
I125	I126	I131	I133	In114m	
Ir192	Mn54	Na22	Pa230	Pb212	
Ra224	Ru106	Sb124	Sb124	Sb125	
Sc46	Sr89	Sr90	Ta182	Ta182	
Tb160	Te127m	Te129m	Th234	T1204	
Tm170	U236	U236	Y91	Zr95	
Any radionuclide that is not alpha emitting and is not included in any other Group in this Schedule					
Group 3					
Ag105	Ag111	Ag111	Ar41	As73	4 mega-becquerels
As74	As76	As77	Au196	Au198	
Au199	Ba131	Ba133	Be7	Bi206	
Bi212	Br75	Br76	Br82	C14	
Ca47	Cd109	Cd115	Ce141	Ce143	
Cl38	Co57	Co58	Cr51	Cs129	
Cs131	Cs136	Cu64	Cu67	Cu67	
Dy165	Dy166	Er161	Er169	Er169	
Er171	Eu152m	Eu155	F18	Fe52	
Fe55	Fe59	Ga67	Ga68	Ga72	
Gd153	Gd159	Hf175	Hg195m	Hg197	
Hg197m	Hg203	Ho166	I123	I130	
I132	I134	I135	In111	In115	
In115m	Ir190	Ir194	K42	K43	
Kr85m	Kr87	La140	Lu177	Mg28	
Mn52	Mn56	Mo99	Na24	Nb93m	
Nb95	Nd147	Nd149	Ni63	Ni65	
Np239	Os185	Os191	Os193	P32	
Pa233	Pb203	Pd103	Pd109	Pm147	
Pm149	Pr142	Pr143	Pt191	Pt193	
Pt197	Pt197	Rb81	Rb86	Re183	
Re186	Re188	Rh105	Rn220	Rn222	
Ru103	Ru105	Ru97	S35	Sb122	
Sc47	Sc48	Se75	Si31	Sm151	
Sm153	Sn113	Sn121	Sn125	Sr85	
Sr91	Sr92	Tc96	Tc97	Tc97m	
Tc99	Te125m	Te127	Te129	Te131m	
Te132	Th231	Ti200	Ti201	Ti202	
Tm171	U239	V48	V48	V48	

W181 Y90 Zn65	W185 Y92 Zn69m	W187 Y93 Zr9	Xe135 Yb175	Y87 Zn62	
Group 4					
Ar37 Cu62 In113m Ni59 Rb87 Sr85m Th232 Xe133	C11 Ga68 Kr81m O15 Re187 Sr87m U nat Y91m	Co58m Ge71 Kr85 Os191m Rh103m Tc96m U235 Zn69	Cs134m H3 N13 Pt193m Se73 Tc99m U238 Zr93	Cs135 I129 Nb97 Pt197m Sm147 Th nat Xe131m	40 mega-becquerels

Appendix 18.2

University Radiation Waste Label

Appendix 18.3

Note: *Text that is crossed out is not relevant to a University but is maintained for completeness of the document and to act as reference information.*

Extract of Annex E of the Safety Guide entitled Predisposal Management of Radioactive Wastes (RPS 16)

PRETREATMENT

The first pretreatment operation should be to collect the radioactive waste and segregate items on the basis of radiological, physical, chemical and pathogenic properties. Waste containing predominantly short-lived radionuclides should not be mixed with long-lived waste.

Segregation is only worthwhile if the segregated wastes will be treated differently as they move through the waste management steps to disposal or if waste acceptance criteria for disposal are likely to be different.

Knowledge of the processes generating the waste may provide adequate knowledge of the radioactivity and radionuclides in the waste. If this is not sufficient the waste should be characterised. The initial characterisation could be based on knowledge of the process generating the waste and the radionuclides involved in the process, combined with dose rate and perhaps preliminary gamma spectroscopy. This initial characterisation could provide enough information to allow disposal or storage options to be determined.

Wastes of different types and radioactivity concentrations (or total radioactivity in the case of sources) may be segregated (Section 4.3) to facilitate waste management according to the overall waste management strategy and the available facilities.

Considerations for segregation include:
• radioactivity concentration: higher radioactivity waste separated from lower radioactivity waste;
• radioactive decay: waste containing long-lived alpha emitters should be separated from waste with no alpha emitters;
• form: solid, gaseous and liquid wastes are treated separately;
• combustible or non-combustible;
• compressible or non-compressible;
• metallic or non-metallic;
• fixed or non-fixed surface contamination;
• materials and objects that are pyrophoric, explosive, chemically reactive or otherwise hazardous;
• items containing free liquids or pressurized gases;
• waste containing infectious agents or is regulated as medical waste; and
• animal carcasses and putrescibles materials.

A more definitive characterisation should be undertaken prior to any treatment and/or conditioning. This characterisation should be sufficiently comprehensive to provide adequate information for assessing treatment steps and demonstrating compliance with the Transport Code (ARPANSA 2008) and disposal waste acceptance criteria.

If all radionuclides in a waste package have half-lives less than about a year, consideration should be given to storing the waste in a storage facility approved by the regulatory authority until radioactivity has decayed to exemption levels.

Other actions undertaken in pretreatment could be to adjust the characteristics of the waste to make it more amenable to further processing and to reduce or eliminate certain hazards posed by the waste owing to its radiological, physical, chemical or pathogenic properties.

Larger items with limited contamination can sometimes be decontaminated to reduce the volume of waste. Mechanical, chemical and electrochemical methods can be used to remove surface contamination from a large

item. The decontamination process should be planned to ensure that the characteristics of the secondary waste are compatible with the requirements for future management. The assessment as to whether to undertake decontamination should take into account the total amount of waste that will be generated by the decontamination (including any plastic sheeting, cleaning equipment, and liquid waste) and doses to workers from the decontamination.

Some items can be disassembled to remove smaller radioactive components or contaminated items from a larger volume of non-radioactive material.

Waste acceptance criteria for disposal are likely to contain exclusions for PCBs, hazardous materials, infectious waste, putrescible waste and explosive materials; and limits on some combustible materials, lead and lead compounds, surfactants, flammable liquids, pressurised gases, chelating agents, organic liquids and free liquids. Estimates of these and similar hazardous and/or toxic components should be determined from process knowledge or direct measurement, and the information documented and stored with the inventory so that it is available when the waste is sent for storage and disposal.

~~In the hospital environment, linen including bedding, towels and personal clothing which may be contaminated with radioactive materials should remain segregated from other linen and waste until it has been monitored. If found to be contaminated, the article should be stored for decay until the amount of radioactivity is below the exemption limit [Schedule 4 of the *National Directory for Radiation Protection* (ARPANSA 2004)] for the particular radionuclide. At that time the article can be laundered with other linen or disposed of as non-radioactive waste including return to the owner.~~

LIQUID WASTE

Liquid radioactive waste can be generated in laboratory or medical applications of radioactive materials. Limited quantities of aqueous liquids with low concentrations of radioactive material may be suitable for discharge to the sewer, under the requirements and limits for discharge of radioactive waste by the user proposed to be included in Schedule 8 of the *National Directory for Radiation Protection*. Liquid waste potentially containing radioactivity which would cause the discharge exemption limit to be exceeded should be collected and stored for decay or other treatment determined by the chemical, physical and biological hazards of the liquid including the radionuclide half life.

Where aqueous liquid radioactive waste is regularly produced in a laboratory at a level where the effluent from laboratory sinks may conceivably cause the discharge to the sewer to exceed the proposed exemption level, sinks should be connected to a holding or delay tank system and these sinks should be restricted to uses involving radioactive materials. Where the volume of liquid radioactive waste is small, a labelled screw top container in the working area may be adequate.

~~Toilets used by inpatients being treated with radioiodine should be clearly marked and only used by those patients. Acknowledging that single rooms within hospitals are a valuable resource, such designated toilets when not in use by patients undergoing radioiodine therapy treatment may be safely used for other patients if monitored and decontaminated correctly. If the effluent from these toilets may cause the exemption limit for discharge of iodine-131 from the premises to the sewer to be exceeded, the relevant regulatory authority may require that the toilets be connected to a holding tank system. The radioactivity and volume of the tank contents should be monitored continuously. Sufficient time should be allowed for decay of stored iodine-131 to below the exemption level for discharge to the sewerage system before a tank is emptied.~~

Holding tanks for short-lived radionuclide wastes are usually constructed in sets of two or more, so that one may be filling while the contents of a full one may be discharged after sampling or elapse of a sufficient period for radioactive decay.

Tanks for temporarily holding liquid waste should:

- be leak-free;
- have visual indicators of the volume of the contents and warning devices to indicate when the tank is almost full;

- be enclosed in a secondary enclosure of sufficient volume to hold the contents if at any time there should be a loss of tank contents;
- have facilities to monitor the amount of radioactivity or to allow easy withdrawal of representative samples;
- have a means to allow inspection of build-up of deposits on the base or sides and to allow access for clearing (incorporation of mechanical agitators may reduce the incidence of deposits); and
- have sanitary controls and methane monitoring if the tank holds human or animal wastes.

Liquid waste should be characterised on the basis of process knowledge and preliminary measurement. Mixing liquid waste streams should be limited to those streams that are radiologically similar and chemically compatible. It is usually preferable to treat a small amount of more concentrated liquid waste rather than treat the large volume created when the more concentrated liquid is mixed into a larger volume of liquid with low or very low levels of radioactivity.

Aqueous liquid waste streams should not be mixed with organic liquid waste. Organic liquid waste may be flammable, and its collection and storage should incorporate provisions for adequate ventilation and fire protection.

The non-radiological characteristics of liquid waste should be assessed to determine if there are other hazardous components in the waste that limit the management options for the waste.

TREATMENT

Treatment of laboratory waste may include:

- volume reduction by compaction of solid waste, by disassembly of bulky waste components or equipment, and by incineration of combustible waste;
- concentration and collection of radionuclides from liquid and gaseous waste streams by evaporation or ion exchange for liquid waste streams and filtration of gaseous waste streams; and
- change of form or composition by chemical processes such as precipitation, flocculation and acid digestion as well as chemical and thermal oxidation.

In general, treatment of radioactive waste requires approval from the regulator before any treatment or conditioning is undertaken. In some cases, this could already be included under an existing licence; in others, specific approval will be required.

Compaction can be an effective method for reducing the volume of a compressible waste. The characteristics of the material to be compacted and the desired volume reduction should be well defined and controlled. Issues to be taken into consideration in assessing the safety of compaction should include:

- possible release of volatile radionuclides and other airborne radioactive contaminants as gases or dust;
- possible release of contaminated liquid during compaction;
- chemical reactivity of the material during and after compaction; and
- potential fire and explosion hazards due to pyrophoric or explosive materials or pressurized components.

Disassembly and other size reduction techniques may be used for waste that is bulky or oversized in relation to the intended processing. Processes for size reduction can include sawing, hydraulic shearing, abrasive cutting, plasma arc cutting and cutting with high temperature flames. Preventing the spread of particulate contamination should be considered in the choice of method and in the operation of the equipment.

Combustible solid waste and radioactive organic liquids may be incinerated, calcined or treated with other advanced oxidation techniques suitable for reducing the volume of waste and producing a stable waste form. After incineration, calcination or advanced oxidation, radionuclides from the waste are distributed between the residue, the products from cleaning the exhaust gases and any stack discharges. The distribution of radioactivity and other combustion products to each of these waste streams should be assessed for all normal and abnormal conditions. Any proposal for incineration, calcination or other advanced oxidation technique should be referred to the regulator for approval.

If the radioactive waste contains fissile material, the potential for criticality should be evaluated and eliminated by means of design features and administrative controls.

Used filters from treating gases at facilities using radioactivity are a solid radioactive waste. Care should be taken to ensure that radioactive materials trapped on filters are not dispersed during handling the filters or the subsequent treatment of filters. Many filters will have only low levels of radioactivity and it may be worth assessing whether the level of radioactivity is below the exemption levels given in the *National Directory for Radiation Protection* (ARPANSA 2004). Filters containing radioactivity can usually be compacted to reduce the volume of radioactive waste to be managed.

For any waste management process that potentially leads to airborne emissions, stack discharges should be monitored to ensure that the concentrations and amounts of radionuclides discharged are within the limits specified by the regulatory body and are consistent with the parameters modelled in the safety assessment.

Animal carcass waste might be incinerated or treated with lime and absorbent. Specific absorbents are available for dealing with biological material, and the specific instructions should be followed.

Treatment of Liquids

Long-lived liquid radioactive waste requiring storage should be converted to solid form as soon as practicable. Solid waste is easier to store safely and, as shown in Annex G, a repository for waste disposal is likely to only accept solid waste with limits on the amount of free liquid.

Treatment of organic liquid waste, e.g. contaminated oil, depends on the organic liquid involved so relevant advice on treatment options should be sought. Methods for converting radioactive aqueous liquid waste to a solid form include:

- chemical precipitation, for example precipitating the radioactive component as hydroxide by raising pH;
- evaporation of liquid and management of the residue as solid radioactive waste;
- incorporation into a matrix, e.g. added to a sand cement mortar, bitumen polymer, ceramics or glass;
- adsorption of radioactivity onto a solid, e.g. alum followed by centrifuging to separate the solids from the liquid;
- the use of ion exchange resin; and
- filtration, ultrafiltration and reverse osmosis.

Chelating agents, organic liquids or oil and salt content in liquid waste may also be of concern in some conditioning processes.

Conditioning

Conditioning laboratory waste may include the conversion of the waste to a solid waste form, enclosure of the waste in containers, and, if necessary, provision of an overpack. Conditioning could also be encapsulation of contaminated items in an inert matrix, such as a cement or mortar.

Twenty litre, 60 litre and 205 litre steel drums are the preferred package sizes for laboratory radioactive waste. Galvanised or stainless steel drums have greater resistance to corrosion and may be preferred. A safety assessment should be performed to ensure that the drum selected is suitable for the particular waste type. Other sized packages or type of package should be used if the safety assessment demonstrates a significant advantage in doing so. A generator producing small amounts of radioactive waste might use smaller packages, but the smaller packages selected should be able to be packed into larger drums for ease of subsequent handling. If larger packages are indicated, future transport and handling requirements should be considered before deciding to use larger packages. Consideration should be given to cutting larger items to fit into a 205 litre drum.

The dose rate on the outside of the package containing radioactive waste should be measured to ensure the package is suitable for the storage facility and the proposed mode of transport. Some waste may need to be encapsulated in cement mortar to reduce the contact dose rate on the outside of the package. Alternatively, additional temporary shielding and control procedures could be used to control access to areas with higher dose rates.

Waste packages produced by conditioning should satisfy the criteria for transport, storage and disposal. To the extent practicable, conditioning of radioactive waste should produce a waste package with the following characteristics and properties:

- physical and chemical properties of the waste are compatible with any matrix materials and the container;
- low voidage;
- low permeability and leachability;
- chemical, thermal, structural, mechanical and radiation stability will be maintained for the required period of time;
- resistant to chemical substances and organisms;
- suitable for retrieval at the end of the storage period;
- suitable for transport to and handling at a disposal facility; and
- ~~meets waste acceptance criteria of the disposal facility, or if the disposal facility is not yet established, meets the generic waste acceptance criteria in the *Code of Practice for Near-Surface Disposal of Radioactive Waste in Australia* (NHMRC 1992).~~

Some materials require specific assessment before being encapsulated in concrete. Aluminium, magnesium and zirconium are known to react with the alkaline water of a cement slurry or water diffused from a concrete matrix to produce hydrogen.

The container may also need to provide radiation shielding. The selection of materials for the container and its outer surface finish should consider the ease of decontamination. An additional container or an overpack may be needed to meet the acceptance criteria if the container does not meet the relevant criteria for transport, storage or disposal. Any such package should be designed to maintain integrity and containment of the radioactivity for an extended period of storage if there could be a significant delay before an acceptable disposal route becomes available.

DISPOSAL

~~Most laboratory and medical radioactive wastes have a sufficiently low radionuclide concentration to be accepted at a near-surface disposal facility.~~

~~Other disposal options include delay/decay to below exemption levels for clearance or disposal in accordance with Schedule 8 of the NDRP (ARPANSA 2004).~~

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Handling, investigation and reporting of radiation incidents
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S19
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, incident, emergency, accident
SUMMARY *Brief summary of the contents of the document*	Procedures for the handling, investigation and reporting of radiation incidents

INDEX – Section 19

1. BACKGROUND

It is a legal requirement to report radiation incidents to the EPA if they meet the requirements outlined in 1.2.

NOTE: Radiation accident – an unplanned or unexpected emission of radiation (including spillage or leakage of a radioactive substance or damage to radiation apparatus), or misuse of radiation apparatus or maladministration of a radioactive substance used for therapeutic or diagnostic purposes.

1.1. Possible types of incidents

Incidents can occur that result in one or more of the following events:

- Radiation exposure of a member of staff, student or visitor
- Incorrect radiation exposure of a volunteer
- Radioactive contamination of one or more persons and/or the environment
- Loss of a radioactive source (including suspected theft).
- Near misses are also included in this process in order to mitigate future radiation accidents.

1.2. Definitions of a radiation accident in the NSW Radiation Control Regulation 2003

The legislative definition of a radiation accident or incident as per the NSW Radiation Control Regulation 2013 is as follows:

Division 5 Radiation accidents - Clause 37 Certain occurrences are taken to be radiation accidents.

(1) For the purposes of this Regulation, a ***radiation accident*** is to be treated as having occurred if there is an occurrence that involves the unplanned or unexpected emission of radiation (including spillage or leakage of a radioactive substance or damage to radiation apparatus) and that is of such a nature or extent that it is likely:

(a) that one or more persons have, or could have, received an effective dose of radiation equal to or in excess of:

(i) 5 millisieverts, in the case of an occupationally exposed person, or
(ii) 1 millisievert, in any other case, or

(b) that the premises or the environment may have become contaminated within the meaning of section 21 of the Act.

(2) For the purposes of this Regulation, a ***radiation accident*** is to be treated as having occurred if there is an occurrence that involves the misuse of radiation apparatus or maladministration of a radioactive substance used for medical purposes and that involves any of the following:

(a) the administration of a radioactive substance for diagnostic purposes in a quantity of more than 50 per cent more than that prescribed,

(b) the administration of a radioactive substance for therapeutic purposes at an activity differing by more than 15 per cent from that prescribed,

(c) the administration of a therapeutic dose of radiation from radiation apparatus or a sealed source device which differs from the total prescribed treatment dose by more than 10 per cent,

(d) the administration of a dose of radiation for diagnostic and interventional purposes from a radiation apparatus that results in one or more persons receiving an effective dose of radiation equal to or in excess of 1 millisievert,

(e) the unintended administration of radiation as a result of a malfunction of radiation apparatus,

(f) the administration of a radiation dose to the wrong patient or to the wrong part of a patient's body,

(g) the administration of a radiopharmaceutical otherwise than as prescribed.

2. RESPONSIBILITIES

2.1. The Radiation Management Licence Holder

It is the ultimate responsibility of the RML holder to ensure that accidents and incidents are investigated and reported, and that all using radiation are fully trained and are cognisant of their responsibilities.

The RML holder has delegated this task to the CRTC.

2.2. The Radiation Safety Officer

The RSO will assist in the response to the incident and will be responsible for ensuring that the incident and details of the radiation levels/exposures are reported to the RML Holder via the Manager Health & Safety.

2.3. The Associate Director, Employee Relations and Work, Health and Safety

The Associate Director, Employee Relations and Work, Health and Safety will be responsible for reporting all incidents to the Radiation Management Licence Holder (DVCR&I) and to the EPA, if required.

2.4. The Technical manager or equivalent of the facility

The Technical Manager or equivalent must ensure that any person using the facility has had training regarding a radiation accident and has demonstrated competency for the local conditions regarding possible incidents.

2.5. The Radiation User Licence Holder

The Radiation User Licence holder must follow the procedures detailed below, report the incident as soon as practicable and provide information to authorised officers (HSW and/ or EPA) investigation the incident.

PROCEDURE

Immediately following an incident or accident

(a) Any person becoming aware of an incident or accident shall immediately:

i). Take steps to minimise further contamination, if safe to do so,

ii). Inform all people in the laboratory,

iii). Inform the technical manager,

iv). Inform the Chief Investigator/Responsible Academic, and

v). Inform HSW

(b) All persons not involved with the accident/incident should move to the designated assembly point A.

(c) Persons suspected of being contaminated by radioactive material are not to leave the facility but are to move away from the site of contamination. If there is a risk of injury from fire, gas release or toxic materials (other than radiation) then the area is to be evacuated with those contaminated being isolated away from the site.

(d) If it is obvious that first aid is required, contact a first-aid officer.

(e) If it is an emergency dial 000

2.6. Typical protocol for Decontamination of Persons

The Designated Facility Manager/ Safety Coordinator must be involved in the following.

NONE OF THE FOLLOWING IS TO OCCUR WITHOUT FIRST CONSULTING THE RSO IF AVAILABLE.

Any obvious injuries should be treated immediately, taking care to avoid the spread of contamination to wounds, eyes, nostrils or mouth.

Contaminated clothing should be removed and a contamination survey of the person should be performed. Personal decontamination should be undertaken according to the area(s) of the body contaminated, as follows:

(a) eyes should be irrigated with saline solution (a 0.9 percent sodium chloride solution), or with distilled or mains water;

(b) hands should be washed with tepid water and mild soap or handwash solution (preferably neutral pH). If this is inadequate, repeat once or twice.

Contaminated fingernails may be scrubbed lightly with a soft nail brush. For contamination that is difficult to remove, disposal rubber gloves may be worn for several hours to promote perspiration of the hands, which may assists in removing of contamination while preventing its spread to other surfaces;

(c) skin, other than that of the hands, should be swabbed gently with a cotton wool pad soaked in a mild soap or handwash solution (preferably neutral pH) and rinsed well. Do not vigorously scrub the skin or use detergents as this may affect the natural skin barrier and increase the risk of internal contamination;

(d) contaminated wounds should be washed under a fast running tap. If the wound is on the face, care should be taken not to contaminate the eyes, mouth or nostrils. Finally a gentle antiseptic and a waterproof dressing applied; and

(e) attempts to remove all contamination from skin may not be feasible or desirable. Some radioactivity may be trapped in the outermost layers and will remain until normal sloughing occurs (12-15 days). Personal decontamination should be continued until monitoring shows that less than 10% of the residual contamination is removed at each cycle, unless there is the risk of the contamination entering the bloodstream through the roughening or breaking of the skin.

2.7. Decontamination Of Surfaces Or Contaminated Equipment

Consultation with the RSO is a necessary requirement before any decontamination is conducted.

See Section 6 Laboratories for Spill Procedures.

2.8. Investigation and Reporting Requirements

All incidents must be reported to HSW (AIMS) and subsequently investigated, including ‘near misses’, to minimise the likelihood of such incidents occurring again. The investigation should be aimed at:

(a) establishing what happened;

(b) identifying the failure;

(c) deciding on remedial action to minimise the chance of a similar failure; and

(d) estimating the likely radiation doses received by staff, student and/or member of the public.

2.8.1. All incidents including ‘near misses’ will be investigated by the RSO together with HSW, the facility manager and the chief investigator/responsible academic. And an incident report form (radiation) completed and sent to HSW within 24 hours of the incident. This form includes:

i). date, time and place of the incident and the period during which emission of radiation was uncontrolled;

ii). a description of the incident including particulars of the area over which any radioactive substances may have been dispersed;

iii). particulars of any steps taken at the time of the incident to rectify the accident;

iv). names, addresses, contact details of persons involved including witnesses

v). details of any injuries ; and

vi). estimation of the likely radiation doses received by staff, student and/or member of the public.

2.8.2. Any person accidentally irradiated must be informed by HSW Unit (through interpretation services if required) of the event in writing (includes electronically) and their likely exposure. Expert advice and independent counselling as to the likely implications of the unintended exposure will be offered.

2.8.3. The Chief Investigator/Responsible Academic in consultation with HSW shall review the radiation safety processes and shall update the current risk assessment, control procedures, and document and organise additional training for staff or students to minimise the likelihood of a repeat of the incident.

2.8.4. HSW will send a copy of the Incident Report to the chair of the CRTC to be evaluated executively and tabled at the next CRTC meeting.

2.8.5. HSW shall add the Incident Report to the Register of Radiation Incidents.

2.8.6. The Chief Investigator/Responsible Academic will send to the CRTC any updated risk assessments, additional control procedures, and any additional training for staff or students as proposed amendments to their CRTC application for approval.

2.8.7. **Certain radiation incidents must be reported to the EPA**. HSW Unit in consultation with the RSO shall determine whether a particular incident must be reported.

If a report to EPA is required:

i). The EPA shall be notified by HSW in consultation with the RSO in writing within forty-eight hours of a radiation accident occurring. This is most easily achieved by sending an email to radiation@environment.nsw.gov.au.

ii). A copy of this notification must be sent to the DVC(R&I).

NOTE: The HOD, Associate Director, Employee Relations and Work, Health and Safety and the DVC(R&I) shall be notified immediately if the accident involves an injury or illness to workers, where Workers Compensation is or may be payable. The NSW WorkSafe shall be notified immediately by HSW if a radiation accident causes a fatality, serious injury or illness to workers or was immediately life threatening but without fatality or serious injury.

2.8.8. If an accident has been notified to EPA, a full report must be prepared by HSW in consultation with the RSO for the EPA, following the accident investigation, which includes the following requirements (Section 27 of the Regulation):

- particulars of the accident, indicating, as far as possible, the place where it occurred and the period during which emission of radiation was uncontrolled;
- particulars of the area over which any radioactive substances may have been dispersed;
- particulars of any steps taken to rectify the accident;
- particulars of any personal injury or exposure that may have resulted;
- particulars of any assessment of the radiation dose to which any person may have been exposed as a result of the accident; and
- particulars of all measures put in place to prevent a recurrence of the accident.

This report must be sent to EPA within 10 days of the incident and a copy of this report must be provided to the DVC(R&I), Associate Director, Employee Relations and Work, Health and Safety, CRTC and the HOS.

CONTACT DETAILS OF HSW and the RSO

		After Hours
HSW (Associate Director, Employee Relations & W, HSW)	4913 8140	Security 4921 5888
HSW (Senior Safety Adviser)	4921 6846	Security 4921 5888
University of Newcastle RSO/RPA (Mr W Bartolo)	0427287630	Security 4921 5888

DOCUMENTATION

University of Newcastle On-line Accident/Incident reporting/form

AUDIT

All Radiation incident reports are to be tabled and discussed at the CRTC
Every 2 years for a full audit of records

REFERENCES

NSW Radiation Control Regulation 2013

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Nov., 2014	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
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April 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March 2018	Revision 6	Melissa Musicka, & William Bartolo, Bartolo Safety Management Service
May 2019	Revision 8	Melissa Musicka, & William Bartolo
Nov., 2021	Revision 9	Melissa Musicka, & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Radiation Safety Training
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S20
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation Safety Training
SUMMARY *Brief summary of the contents of the document*	Requirements for training to ensure radiation safety at the University.

INDEX – Section 20

1. BACKGROUND

For the University to hold and maintain a radiation licence they are obliged under NSW Legislation to ensure that individuals are trained by an approved or accredited radiation safety trainer and to keep records of such training. Training is also required for those who are granted licence exemptions.

The University uses radiation for research, scientific and teaching purposes. **All personnel involved with such activities must** have the appropriate training (as supplied through HSW or external providers) to ensure:

(a) that radiation training is current

(b) an understanding of the radiation that they are dealing with

(c) an understanding of record keeping procedures

(d) ensure appropriate knowledge for handling, storage and disposal of such radiation

(e) that exposure to radiation is mitigated

(f) an understanding of their responsibility regarding radiation to the University and the wider community

(g) have appropriate knowledge to respond to an emergency.

2. RESPONSIBILITIES

The Radiation Management Licence Holder and HSW

Ensure that training occurs and that records of training are kept including copies of certificates issued to individuals.

Head of School/Department

Will ensure that all radiation workers, and exempted students, contractors, visitors, for whom they are responsible and entering a radiation facility have appropriate training, professional qualifications and/or accreditations.

Chief Investigator/R4esponsible Academic And/Or User Licence Holder

Is responsible for ensuring that

- all radiation workers (and exempted students) identified on their approved project have the appropriate training, professional qualifications and/or accreditations; and
- all records of radiation use are maintained and kept.

The Radiation Worker, Exempted Students, And Contractors

Will ensure that they:

- have appropriate training, qualifications, accreditations, or licences to allow them

to work safely within the designated radiation facility;

- are familiar with and comply with all local guidelines related to safe use, storage and disposal of their particular isotope and equipment in their facility.
- maintain and keep records of their radiation use

Radiation Safety Officer

The radiation safety officer will oversee and provide advice on radiation training for all personnel as required.

Note: legislation implies that training must be updated on a regular basis (typically 2, 3, or 5 year periods depending upon the nature of the radiation involved).

PROCEDURE

2.1. Radiation Training for staff and students involved in the use of radiation

Chief investigator or equivalent will contact the:

- HSW to discuss training requirements for radiation usage.
- Facility manager to discuss training requirements for the specific facility usage

Note: A typical radiation safety training program includes:

- An outline of radiation physics basics
- Radiation Interaction
- Detection and measurement
- Legal/ICRP dose limits
- The legal Units
- Unsealed Source safety (if appropriate)
- Laboratory safety
- Sealed and X-ray analysis Equipment safety (if appropriate)
- Current legal requirements.
- Record keeping and maintenance

Once radiation training run at University of Newcastle is satisfactorily completed, the training provider will send a record to the HSW of the training, and copies of certificates will be issued to individuals. The individual is to supply a copy of their certificate to the Chief Investigator/Responsible Academic and Facility Manager for their records.

Individuals attending radiation training run by other certified providers must supply a copy of their training certificate to HSW, the Chief Investigator/Responsible Academic and Facility Manager for their records.

Note: Certificates typically include:

- the name of the individual
- type of training
- date
- level of achievement of the individual.

- A unique certificate number

Note: If applying for a user licence from the NSW Authority, do not send the original certificate (send a certified photocopy) as no material included in the application is returned to the applicant.

DOCUMENTATION

Records of staff training to be kept by HSW and the facility manager.
Local department induction training specific to particular equipment and local business rules to be documented and stored with review dates noted.

AUDIT

Every 2 years

REFERENCES

ICRP 2000a. *Avoidance of radiation injuries from medical interventional procedures*, ICRP Publication 85, Annals of the ICRP, 30 (2).

Wagner LK and Archer BR 2000. *Minimising risks from fluoroscopic X-rays*, 3rd Edition, Partners in Radiation Management, Woodlands, Texas.

ICRP 2000c. *Managing patient dose in computed tomography*, ICRP Publication 87, Annals of the ICRP, 30 (4).

ICRP 2007. *Managing patient dose in multi-detector computed tomography (MDCT)*, ICRP Publication 102, Annals of the ICRP, 37 (1).

NSW Government (2013) "Radiation Control Regulation"

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Jan., 2015	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March 2018	Revision 6	William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Ms Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Ms Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	**Radiation Safety Records**
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S21
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, ionising radiation, X-rays, radioactive substances, records
SUMMARY *Brief summary of the contents of the document*	Procedures to ensure that all records relating to radiation safety are maintained in compliance with the appropriate legislation

INDEX – Section 21

1. BACKGROUND

This procedure will list the legally mandated recordkeeping requirements with regard to radiation safety.

The Storage of records, including records of staff occupational exposure:

- Records referred to in points 4.1 – 4.6, 4.8 - 4.12, and 4.14 must be kept until such time as the Director-General of the EPA gives consent to dispose of them.
- All records referred to in points 4.6, 4.8 – 4.10 must be kept at the site of the registered device, apparatus or premises for a period of 6 years after the event requiring documentation. Once a project is completed the records are required to be transferred to the HSW for archiving and keeping centrally for the University and the RML.

The University has implemented “Historion” software for many of these records and processes.

2. RESPONSIBILITIES

Department Heads For Schools/Departments/Centres Using Radiation

The Head of School (HOS), PVC or Head of Division will ensure that the following records are kept and maintained (those that have HSW in red are required to have a copy forwarded to the University of Newcastle Health and Safety Team every 6 montHSW). The process will be to forward a copy of the inventory to Health and Safety (electronic is acceptable) and indicate clearly in that copy that it has not been changed since the last submission or that it has been changed and highlight the changes:

i). Register of User Licenses (HSW**)

ii). Register of Student Exemptions **(**HSW**)**

iii). Register of Personal Monitoring **(**HSW – every three months****)**

iv). Inventory of Unsealed Sources **(**HSW**)**

v). Inventory of Sealed Sources **(**HSW****)**

vi). Inventory of X-ray equipment (all equipment that has an x-ray tube or X-ray capability) **(**HSW****)**

vii). Register of Radioactive Waste **(**HSW**)**

viii). Register of Facilities (laboratories, radiation stores, etc) **(**HSW****)**

ix). Record of use of facilities

x). Record of Contamination and Area Monitoring

xi). Register of Ionising Equipment Repairs, Calibrations and Certifications

xii). Register of Clinical Equipment QA tests

xiii). Register of Portable and Non-portable radiation monitors and detectors **(**HSW**)**

xiv). Register of Monitor and Detector repairs and calibrations

xv). Register of Projects and Teaching involving Radiation including Approval Numbers

xvi). Radiation Accident/Incident Reports **(**HSW within 12 hours of the situation**)**

xvii). Register of Facilities Inspections

** - University of Newcastle uses Historion for these records and where arranged the local appointed administrator is responsible for entering the records or data at the appropriate times or intervals.

User License Holders

User License Holders are to keep and maintain all records regarding the usage, storage, waste, equipment maintenance, purchase, disposal, monitoring of radiation or radiation equipment associated with their project. They should be in accordance with the above list.

3. RECORDKEEPING

3.1. Register of User Licenses

This register is to contain the following details:

(a) Name of the Licensee

(b) License Number

(c) Active/Expired/Terminated

(d) Date of Expiring

(e) License details

(f) Radiation Safety Training Details

3.2. Register of Exemptions

This register is to contain the following details:

(a) Date of Issue of Exemption

(b) Name of Exempted Person

(c) Student details (Full student name, Student number, Course, Approved project number)

(d) Location of use of radiation

(e) Radiation details

(f) Name of User Licensee who is granting exemption and has the legal authority to do so and license number

(g) Name of radiation supervisor who has the authority to supervise and license number

(h) Copy of the written exemption for each person

3.3. Register of Personal Monitoring

Please note that the University now uses “Historion” for this record keeping.

Personal monitoring records for each person issued with a dosimeter must be kept and maintained. The record must contain the particulars from Clause 18 of the Radiation Control Regulation. The Details are:

(a) the full name, sex and date of birth of the occupationally exposed person,

(b) the current home address of the occupationally exposed person or, if the person is no longer employed by the employer, the person’s last known home address,

(c) the date of commencement of employment (and, if applicable, the date of cessation of employment) as an occupationally exposed person,

(d) the kind of work performed by the occupationally exposed person,

(e) details of the types of ionising radiation to which the occupationally exposed person may have been exposed in the course of employment with the employer, including information about radioactive substances in unsealed form (if any) to which the occupationally exposed person may have been exposed,

(f) details of any radiation accidents in which the person has been involved or by which the person may have been affected,

(g) details of the personal monitoring device worn by the occupationally exposed person, and

(h) the results of monitoring the levels of radiation exposure of the occupationally exposed person which will include date, type(s) of radiation, badge result, lifetime result and 5 year rolling average.

The University of Newcastle has purchased and installed the software “Historion” for the management and storage of radiation data, most importantly the personal dosimetry records. Contacts in each management area are identified, appointed and trained to be able use this system and to enter/access the required information into the database for their area.

It is also the responsibility of this appointed person to ensure that when a monitored worker from their area leaves the University, they are provided with a copy of the radiation exposure record (a “Historion” dose report).

For more information please contact HSW.

3.4. Inventory Of Radioactive Sources And Radiation Apparatus

A documented inventory of all radioactive sources, substances and radiation apparatus must be kept and up to date. The specific requirements for the Unsealed and Sealed Source inventory are:

(a) Location and records of transfer of location including date of transfer
(b) Date of Receipt
(c) Calibration Date
(d) Sealed Source ID Number
(e) Isotope
(f) Chemical form and concentration
(g) Total activity
(h) Specific activity
(i) Date completely used or exhausted

The specific requirements for the Ionising Equipment inventory are:

(a) Date of Receipt
(b) Calibration Date and Date of Certification if Clinical
(c) Certificate of Compliance, if clinical
(d) Registration Number
(e) Equipment, Equipment Type, Brand, Model, Serial Number
(f) Location
(g) Date Disposed, Decommissioned or traded

3.5. Register of Radioactive Waste

The register is to contain sufficient detail so that University RSO and HSW can ascertain the ability of disposal. The details required are:

(a) Location and records of transfer of location including date of transfer
(b) Date of becoming waste
(c) Isotope(s)
(d) Concentration and details mixture
(e) Specific Activity or total activity
(f) Chemical form (solid or liquid, chemical details)
(g) Signature of user of the material being declared as waste

3.6. Register of Facilities

All facilities (designated radiation areas, laboratories, radiation stores and radioactive waste stores) once inspected by the University RSO and HSW and certified will require a Record of these facilities. This record will contain the following information:

(a) Type of facility (low, medium, high)

(b) Date of inspection and registration

(c) Date of annual inspection

(d) Registration Number

(e) Location (includes site and room number

3.7. Log of Facility Use

Each facility will have a book recording the use of that facility. The following details (as is relevant) will be recorded for each use:

(a) Date

(b) Time

(c) User(s)

(d) Purpose of use

(e) Isotope(s)

(f) Contamination and cleanup

(g) Signature

3.8. Record of Contamination and Area Monitoring

For radioisotope laboratories and facilities it is a legal requirement that contamination monitoring is conducted on a weekly basis. Area monitoring as is required and is usually expected to be at least once during a procedure. The following details are to be recorded:

(a) Location

(b) Date and time

(c) Name of person(s) doing the monitoring

(d) Contamination and area monitoring results

(e) Isotopes used at the time or are being tested for

(f) Decontamination required (Y/N)

(g) Signature of person doing monitoring

3.9. Register of Ionising Equipment Repairs, Calibrations and Certifications

It is a legal requirement that there is a documented record of all repairs, calibrations and certifications (where necessary for clinical use and registration). The information required will depend on the equipment, eg for clinical equipment as is detailed in NSW Guideline 6.

3.10. Register of Clinical Equipment QA tests

Records required are stipulated by the Code for Radiation Protection in Medical Exposure (ARPANSA 2019) or legislation. This will be a summary of all QA tests that are done for each item of equipment.

3.11. Register Of Portable And Non-Portable Radiation Monitors And Detectors

Each School/Department/Centre must keep a record of their radiation monitors and detectors. This record will contain the following information:

(a) Location and records of transfer of location including date of transfer

(b) Date of purchase

(c) Instrument type, brand, model and serial number, and if allocated, the Asset Number.

3.12. Register of Monitor and Detector repairs and calibrations

This record could be combined with the previous register and would contain in addition to the above the following details:

(a) Location

(b) Instrument details

(c) Repair details (problem, symptom)

(d) Repaired by

(e) Calibration details

(f) Calibration results

(g) Signature

3.13. Register of Lead Aprons

(a) Compliance testing on purchase
(b) Local registration
(c) Annual testing

3.14. Register of Projects and Teaching involving Radiation including Approval Numbers

All work (research and teaching) in a School/Department/Centre that involves radiation must be recorded for local information. The details to be recorded are:

(a) Dates of approval period

(b) CRTC record/approval number

(c) Project or Teaching details

(d) Chief Investigator

(e) Project Title

3.15. Record of Radiation Accident and Incidents

It is a legal requirement that there is a central (company/institute) record of all accidents and incidents that involve radiation. There needs to be a record both at the site/School and with HSW. The legal minimum to be recorded is the following:

(a) particulars of the accident or incident, including where it occurred and the period during which there may have been uncontrolled emission

(b) names of any persons witnessing the event, or who may have been exposed

(c) an estimate of any potential exposure doses

(d) details of any medical examinations

(e) particulars of the area over which any radiation may have been dispersed

(f) the time at which the accident/incident was reported

(g) the probable cause of the accident

(h) particulars of the subsequent investigation/s

(i) the steps taken to minimise re-occurrence of a similar accident

At the local level (School, etc) points a), b), e), f), and g) are to be recorded.

3.16. Register of Facilities Inspections

In addition to the central record of inspections, each School, etc is to keep a simple register of inspections that may include:

(a) Date of Inspection

(b) Type of Inspection

(c) Name of the person conducting inspection

(d) Any necessary actions to be immediately addressed

DOCUMENTATION

The records listed above

AUDIT

Every 2 years

REFERENCES

Code for Radiation Protection in Medical Exposure (ARPANSA 2019)

NSW Radiation Control Regulation (2003)

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

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Sept., 2014	draft	William Bartolo, Bartolo Safety Management Service
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April, 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March 2018	Revision 6	Melissa Musicka & William Bartolo, Bartolo Safety Management Service
June, 2018	Revision 7	Melissa Musicka & William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN
COVER SHEET

NAME OF DOCUMENT	**Transport of Radioactive Substances**
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP – S22
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, transport, radiation, radioactive, dangerous goods.
SUMMARY *Brief summary of the contents of the document*	Procedures for the safe transport of radioactive substances.

INDEX – Section 22

Continued over page

1. BACKGROUND

Transport of radioactive materials between, laboratories, hospitals, academic institutions, and other research establishments must be done safely.

Such transport within NSW is governed by the Radiation Control Regulation (2013), which specifies that the transport must conform to the requirements of the Code of Practice for the Safe Transport of Radioactive Material. The current version (2019) is Radiation Protection Series No. C-2 (RPS C-2), which is based on the IAEA Regulations for the Safe Transport of Radioactive Material (2018).

The ARPANSA Safety Guide (SSG-26 & SSG-33) for the Safe Transport of Radioactive Material provides specific guidance on achieving the requirements set out in the Code of Practice.

This document will assist by providing specific safety instructions for consignors, carriers and recipients; and providing information on minimising any radiation consequences in the event of a transport accident.

2. RESPONSIBILITIES

2.1. Responsible Person – Radiation Management Licence Holder (DVCR&I)

The Radiation management Licence Holder is responsible to ensure that:

- all transport of radioactive material is done safely and according to legislation.
- Radioactive material is only transported with his/her authority

2.2. Associate Director, Employee Relations and Work, Health and Safety

HSW will be responsible for maintaining a record of transport of radioactive material associated with University of Newcastle between suppliers, institutions and facilities.

2.3. Radiation Safety Officer

The RSO is responsible for giving advice to all parties on the requirements for safe transport of radioactive materials.

2.4. The Consignor

The person initiating the transport of radioactive material (the consignor) is responsible for compliance with the current ARPANSA Code of Practice for the Safe Transport of Radioactive Material (RPS C-2).

2.5. Radiation User Licence Holder

The person that may have requested the materials or be transporting the materials as part of approved research or teaching project.

3.0 PROCEDURE FOR TRANSPORT BY ROAD

NOTE: The requirements for the safe transport of neutron gauges are included in RMP Section 17 - Safety with Neutron Gauges.

University of Newcastle will adopt the transport guideline developed by NSW HURSOG for

GUIDELINES FOR THE TRANSPORT OF RADIOACTIVE MATERIALS
BY ROAD BETWEEN HOSPITALS, UNIVERSITIES, RESEARCH AND

OTHER MEDICAL ESTABLISHMENTS IN NSW

their members use. The following is the complete document.

In these guidelines, the words "*shall*", "*should*" and "*must*" have the following meanings associated with them:
shall – mandatory legal compliance, *should* – advisable, but not mandatory, *must* – although not legally mandatory, it is expected.

INTRODUCTION

The Code of Practice specifies a classification of "Excepted Packages". Packages in this classification are exempt from many of the stringent requirements which otherwise must be followed.

If a package does not meet the "Excepted Packages" classification, then it must be transported as a "Type A" or "Type B" package. These latter packages must fulfil the detailed requirements of the Code of Practice. Those requirements are more stringent in that the package has to satisfy various performance tests such as drop and penetration tests to demonstrate an ability to witHSWtand the normal conditions of transport. It is suggested that if a type A or type B package has to be transported, then the advice of the establishment's Radiation Safety Officer be obtained, or the Radiation Control Section of the NSW EPA should be contacted for directions.

The University's transport vehicle may be used to transport the package provided the driver has been instructed in how to handle and secure the package in the vehicle and in the actions to be taken in case of an accident or an emergency. Written instructions must also be provided (see the kit in Appendix 22.2)

For departments who may be regularly transporting radioactive materials, three placards should be made according to Figure 1 of Appendix 1, and incorporated into the kit of Appendix 22.2.

Packages with activities lower than those given in the "Exempt Activity" column, of Table 1 in Appendix 22.1 are exempt from regulations. **In NSW the "Activity" exempt from regulation is the "Prescribed Activity" of Schedule 1 of the NSW Radiation Control regulation 2013, and is listed in brackets in the same column of Table 1 in Appendix 1. For compliance throughout Australia, the lower of the 2 values should be used.**

Appendix 22.1 contains relevant extracts from the Transport Code of Practice.

Appendix 22.2 is a kit that may be used in conjunction with the Guidelines.

4. INSTRUCTIONS FOR THE TRANSPORT OF ALL PACKAGES

4.1 Sender

(a) **All transportation of radioactive material must be approved in writing by the HSW prior to transport.**

(b) The material must be packaged appropriately:

i). A liquid must be contained in a sealed **labelled** vial.

ii). The vial or other source must be placed in a labelled shielded (lead etc) container with sufficient liquid absorber. The container will have a close fitting lid and be taped closed.

iii). The shielded container will be placed in a secondary sealable container, packed well with cushioning material, and be labelled radioactive and have a label with the name and activity of the compound, and the date.

iv). The sealed container will be placed within an outer transport box with cushioning material to prevent movement within the box. Seal and label the box.

v). The surface dose rate will be measured and recorded. Possible surface contamination must be checked by a wipe test.

vi). Determine whether the package can be classified as an "**Excepted Package**". See section 5 for excepted packages and Section 6 for non-excepted packages.

vii). Fill in the "**Dangerous Goods Declaration Form**".

viii). Label the package with the name and address of addressee. The package must also bear the sender's name and address.

4.2 Instructions To The Person Organising Transport

(a) **No taxis, motorcycles, or public transport may be used to transport radioactive material.**

(b) A courier should be used to transport the package whenever possible.

(c) A University vehicle may be used to transport the package provided the driver approval from HSW to transport such packages.

(d) Written instructions about emergency procedures must be in the transport vehicle (see kit Appendix 2).

(e) When the matter is urgent, private cars may be used (insurance provisions may apply). A person who is conversant both with the hazards involved and with handling emergency situations, (preferably licensed to use the radioactive material being transported), must either drive the vehicle transporting the material, or must accompany the driver.

(f) The package must be **addressed and handed to a specific licensed person** or their nominee. It must not be addressed generally to a "Department", nor delivered to some specified "area" or "front desk".

(g) The person to whom the package is to be delivered should be advised of the time of despatch and expected delivery time.

5. EXCEPTED PACKAGES

5.1 Instructions to Sender

(a) The activity must be less than the value listed in Table 1 of Appendix 1

(b) The radiation level at any point on the external surface must be less than 5 µSv/h.

(c) The removable radioactive contamination on any external surface must be less than 0.4 Bq/cm^2

(d) The package must bear the marking "**RADIOACTIVE**" on an internal surface in such a manner that a warning of the presence of radioactive material is visible on opening the package.

(e) The consignor shall include in the Dangerous Goods Declaration Form with each consignment, the United Nations Number "**2910**", and for all items the proper shipping name and description of the substance or article being transported shall be included ie:

"**RADIOACTIVE MATERIAL, EXCEPTED PACKAGE**
LIMITED QUANTITY OF MATERIAL"

5.2 Package Design

(a) The package must retain its contents under conditions likely to be encountered during routine transport.

(b) The package shall be so designed in relation to its mass, volume and shape that it can be easily and safely handled and transported. In addition, the package shall be so designed that it can be properly secured in or on the conveyance during transport.

(c) As far as practicable, the packaging shall be so designed and finished that the external surfaces are free from protruding features and can be easily decontaminated.

(d) As far as practicable, the outer layer of the package shall be so designed as to prevent the collection and the retention of water.

(e) Any features added to the package at the time of transport, which are not part of the package, shall not reduce its safety.

(f) The package shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise under conditions likely to be encountered in routine transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole. In particular, nuts, bolts and other securing devices shall be so designed as to prevent them from becoming loose or being released unintentionally, even after repeated use.

(g) The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and with the radioactive contents. Account shall be taken of their behaviour under irradiation.

(h) All valves through which the radioactive contents could otherwise escape shall be protected against unauthorised operation.

(i) For radioactive material having other dangerous properties the package design shall take into account those properties.

6. TYPE A OR TYPE B PACKAGES

Type A or Type B packages must be packaged and labelled in accordance with the Transport Code of Practice.

Type A packages must not have an activity greater than A_1 (for *special form material*, eg a capsule) or A_2 (for other forms - eg liquids and gases) of the radioactive material (see Table 2 in Appendix 1)

If a package has an activity greater than A_1 or A_2, (Table 2) it must be packaged as a Type B package.

6.1 Placards

At least three placards (see figure 22.1 in appendix 22.1) must be displayed on the vehicle.

6.2 Category Labels

Type A packages have category labels attached to two opposite sides. The label to be used depends on the radiation dose rate at the surface and the transport index. The transport index is the maximum radiation dose rate at any point 1 metre from the surface of the package in µSv/h, divided by 10 and then rounded up to one decimal place.

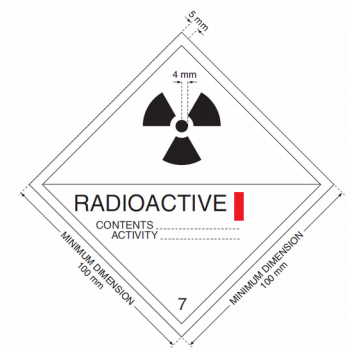
Transport index	Maximum radiation level Category at any point on external surface	Category
0[a]	Not more than 5 µSv/h	I-WHITE
More that 0 but not more than 1	More than 5 µSv/h but not more than 500 µSv/h	II-YELLOW
More that 1 but not more than 10	More than 500 µSv/h but not more than 2000 µSv/h	III-YELLOW

[a] *If the measured transport index is not greater than 0.05, the value quoted may be zero.*

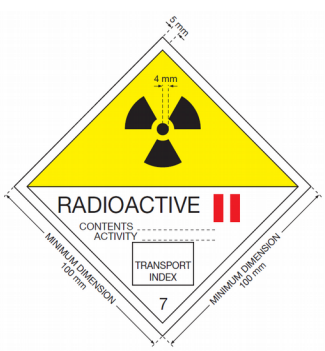
Note: Both the transport index and the surface radiation level conditions are taken into account in determining the appropriate category. Where the transport index satisfies the condition for one category but the surface radiation level satisfies the condition for a different category, the package will be assigned to the higher category.

The category labels will need to indicate the radionuclide, its activity in becquerels and, for category II and III, the transport index.

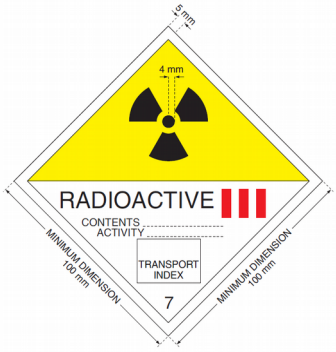
The category signs appear as follows:



Category I-WHITE label



Category II-YELLOW label.



Category III-YELLOW label.

7. NOTES FOR CARRIERS

7.1. CHECK LIST FOR CARRIERS

The following checklist must be completed by carriers before material is accepted for transport. Tick off each item as checked.

(*over page*)

WAYBILL OR CONSIGNMENT NOTE			YES	NO
1.	Consignor's name and address present;			
2.	Consignee's name and address present;			
3.	Note number of package(s) present;	Number =		
4.	Confirm whether consignment note states for instance “Dangerous Goods - Radioactive Substances”, see attached documents (Dangerous Goods Declaration Form).			

PLACARDS		YES	NO
	At least three placards must be available according to Figure 1 in Appendix. 1		

EMERGENCY ROAD HAZARD SIGNS		YES	NO
	At least three Emergency Road Hazard Signs must be available in the vehicle.		

PACKAGES		YES	NO
1.	Correct number of packages are present;		
2.	Contents are packaged properly;		
3.	Packages are correct size and weight;		
4.	Packages are in good condition and seals are intact;		
5.	Check that labels agree with Consignor's Certificate (Dangerous Goods Declaration Form);		
6.	Check that information on transport index, radioactive substances, and activity given on the package label agree with the Consignor's Certificate (Dangerous goods Declaration Form);		
7.	A package containing liquid should have a "'THIS SIDE UP" label if appropriate; and		
8.	The class of the package(s) is marked (e.g. TYPE A, or B) as appropriate.		

DOCUMENTATION		YES	NO
Documentation and other Requirements for the transport of radioactive substances by road are contained in the *Code of Practice for the Safe Transport of Radioactive Material.* The consignor must have all the following documents completed prior to commencement of the transport of the radioactive material.			
1.	Movement order or an equivalent document such as waybill, consignment note, or equivalent.		
2.	Consignor's Certificate (Dangerous Goods Declaration Form):		
	NOTE: A minimum of two copies is required. One is for the carrier and one, within a stout envelope, is to be firmly fixed to the outside of the package for inspection in transit. Where more than one carrier is involved, it may be necessary for each carrier to receive a copy of the Consignor's Certificate.		
3.	Package certification as required.		
4.	Special Form Certificate, if applicable, for sealed sources.		
5.	Competent Authority approval as required.		
6.	Information for carriers – a document which provides: 1. any supplementary operational requirements for loading, transport, storage (away from persons, dangerous goods, livestock and films and for safe dissipation of heat), unloading and handling, or a statement that no supplementary operational requirements are necessary; and		
	2. emergency arrangements specific to the package.		

7.2. LOADING PROCEDURES

(a) Ensure that details of consignment are entered on the carrier's consignment note or waybill. The consignment note should state that "Dangerous Goods - Radioactive Substances, see attached documents (Dangerous Goods Declaration Form)" are being carried.

(b) Use a vehicle that will allow several metres or more distance between the driver (and assistant(s)) and the packages; the greater the distance the better.

(c) The package must be secured on the vehicle. Small, light packages should be stored in a basket while larger, heavy packages should be properly blocked and braced.

(d) Restrictions on the loading of radioactive substances must be observed in regard to segregation from personnel, photographic film, livestock and any dangerous goods that need to be segregated.

(e) The sum of the transport indexes of packages loaded on the vehicle and into freight containers should not exceed 50 unless the material is Low Specific Activity (LSA) or unless other exclusive use conditions are applicable.

(f) Road vehicles, carrying packages, overpacks, tanks or freight containers, must display the placard made according to Figure 1 in Appendix 1 on each of:

(g) at least two external lateral walls in the case of rail vehicles; and

(h) The two external lateral walls and the external rear wall in the case of a road vehicle.. Any placards, which do not relate to the contents, shall be removed. Placards on vehicles should not be obscured.

(i) No passengers are permitted to accompany the driver and his assistant(s) where packages other than those classified as "excepted" are carried.

(j) The vehicle's load should be securely locked or covered during transport.

DOCUMENTATION

Consignors Declaration for Dangerous Goods

AUDIT

Every 2 years

REFERENCES

NSW Radiation Control Regulation (2013).

ARPANSA Radiation Protection Series No. C-2 - Code of Practice for the Safe Transport of Radioactive Material (2019 Edition).

ARPANSA Radiation Protection Series No. SSG-26 Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material

ARPANSA Radiation Protection SSG-33 Schedules of Provisions of the IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition)

ARPANSA Radiation Protection Series No. 14.2 Safety Guide for Radiation Protection in Nuclear Medicine (2008)

ARPANSA Radiation Protection Series No. 14.3 Safety Guide for Radiation Protection in Radiotherapy (2008)

REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Nov., 2014	draft	William Bartolo, Bartolo Safety Management Service
Mar., 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	Ms D Edmunds and Mr W Bartolo
April 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
March 2018	Revision 6	William Bartolo, Bartolo Safety Management Service
Nov., 2021	Revision 9	William Bartolo, Bartolo Safety Management Service

APPENDIX 22.1

ARPANSA RPS C-2

CODE OF PRACTICE

FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL, 2019

Packages with activities lower than those given in the "Exempt Activity" column, are exempt from regulations. In NSW the "Activity" exempt from regulation is the "Prescribed Activity" listed in brackets in the same column.

1.Regulations applying to "Excepted Packages"

- The radiation level at any point on the external surface of the package shall not exceed: **5 µSv/h** (0.5 mrem/h).
- The non-fixed radioactive contamination on any external surface of the package shall not exceed: **0.4 Bq/cm^2**.
- For radioactive material of *special form* (indispersible solid or sealed capsule), other solid forms and liquids the activity must not exceed the limits listed for the radionuclides in TABLE 1 below.

- The package must bear the marking "**RADIOACTIVE**" on an internal surface in such a manner that a warning of the presence of radioactive material is visible on opening the package.
- The documentation shall include the United Nations Number "**2910"**, and for all items the proper shipping name and description ie:

"**RADIOACTIVE MATERIAL, EXCEPTED PACKAGE**
LIMITED QUANTITY OF MATERIAL"

shall be included.

APPENDIX 22.1 (cont.)

TABLE 1
ACTIVITY LIMITS OF SELECTED RADIOISOTOPES FOR EXCEPTED PACKAGES

	Exempt Activity (Prescribed Activity NSW)	Solids		Liquids		Exempt Activity (Prescribed Activity NSW)	Solids		Liquids
		Special Form	Other Form				Special Form	Other Form	
	(MBq)	(MBq)	(MBq)	(MBq)		(MBq)	(MBq)	(MBq)	(MBq)
Americium-241	0.01 (0.04)	10000	1	0.1	Iron-59	1 (4)	900	900	90
Bromine-82	1 (4)	400	400	40	Molybdenum-99	1 (4)	1000	600	60
Caesium-137	0.01 (0.4)	2000	600	60	Phosphorus-32	0.1 (4)	500	500	50
Carbon-14	10 (4)	40000	3000	300	Phosphorus-33	100 (0.4)	40000	1000	100
Chromium-51	10 (4)	30000	30000	3000	Radium-226	0.01 (0.04)	200	3	0.3
Cobalt-57	1 (4)	10000	10000	1000	Samarium-153	1 (4)	9000	600	60
Cobalt-60	0.1 (0.4)	400	400	40	Selenium-75	1 (4)	3000	3000	300
Fluorine-18	1 (4)	1000	600	60	Sodium-22	1 (0.4)	500	500	50
Gadolinium-153	10 (4)	10000	9000	900	Sodium-24	0.1 (4)	200	200	20
Gallium-67	1 (4)	7000	3000	300	Strontium-89	1 (0.4)	600	600	60
Gallium-68	0.1 (4)	500	500	50	Strontium-90	0.01 (0.4)	300	300	30
Germanium-68	0.1 (0.4)	500	500	50	Sulphur-35	100 (4)	40000	3000	300
Indium-111	1 (4)	3000	3000	300	Technetium-99m	10 (40)	10000	4000	400
Iodine-123	10 (4)	6000	3000	300	Thallium-201	1 (4)	10000	4000	400
Iodine-125	1 (0.4)	20000	3000	300	Tritium (H-3)	1000 (40)	40000	40000	4000
Iodine-131	1 (0.4)	3000	700	70	Xenon-133	0.01 (40)	20000	10000	1000
Iron-55	1 (4)	40000	40000	4000	Yttrium-90	0.1 (4)	300	300	30

For radionuclides not listed above, contact the Radiation Safety Officer.
Excepted packages may contain any quantity of natural uranium, depleted uranium or natural thorium, provided that the outer surface of the uranium or thorium is enclosed in an inactive sheath made of metal or some other substantial material.

APPENDIX 22.1 (cont.)

2. Regulations applying to Type A Packages

For radioactive material of *special form* (indispersible solid or sealed capsule) and all other forms the activity must not exceed the limits listed for the radionuclides in TABLE 2 below:

TABLE 2
ACTIVITY LIMITS OF SELECTED RADIOISOTOPES FOR TYPE A PACKAGES

	Special form A_1 (GBq)	Other form A_2 (GBq)		Special Form A_1 (GBq)	Other Form A_2 (GBq)
Americium-241	10000	1	Molybdenum-99	1000	600
Bromine-82	400	400	Phosphorus-32	500	500
Caesium-137	500	500	Phosphorus-33	40000	1000
Carbon-14	40000	3000	Samarium-153	9000	600
Chromium-51	30000	30000	Selenium-75	3000	3000
Cobalt-57	10000	10000	Sodium-22	500	500
Fluorine-18	1000	600	Sodium-24	200	200
Gadolinium-153	10000	9000	Strontium-89	600	600
Gallium-67	7000	3000	Strontium-90	300	300
Gallium-68	500	500	Sulphur-35	40000	3000
Germanium-68	500	500	Technetium-99m	10000	4000
Indium-111	3000	3000	Thallium-201	10000	4000
Iodine-123	6000	3000	Tritium (H-3)	40000	40000
Iodine-125	20000	3000	Xenon-133	20000	10000
Iodine-131	3000	700	Yttrium-90	300	300

For radionuclides not listed above contact the Radiation Safety Officer.

APPENDIX 22.1 (cont.)

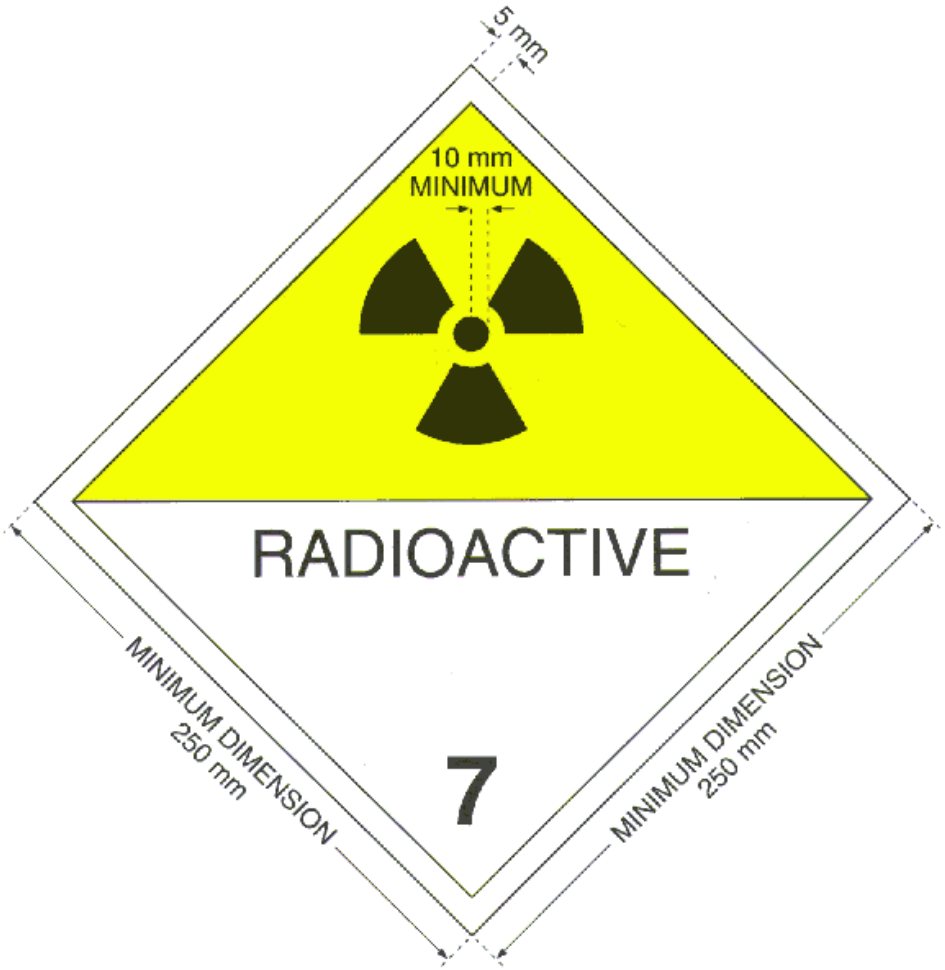
PLACARDS

Road vehicles, carrying packages, overpacks, tanks or freight containers, must display the placard made according to Figure 1 below, on each of the two external lateral walls and the external rear wall in the case of a road vehicle.

Any placards, which do not relate to the contents, shall be removed. Placards on vehicles should not be obscured.

FIGURE 22.1

PLACARDS. The number “7” shall not be less than 25 mm high. The background colour of the upper



half of the placard shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black. The use of the word “RADIOACTIVE” in the bottom half is optional to allow the alternative use of this placard to display the appropriate United Nations number for the consignment.

APPENDIX 22.2

NSW H.U.R.S.O.G.

RADIOACTIVE MATERIAL TRANSPORT KIT AND EMERGENCY PROCEDURES GUIDE

To be read and carried by all transporters of radioactive materials

(*To be kept in the document holder in the driver's door or some place conspicuous in the driver's compartment*)

Transport of radioactive materials by public transport or taxis or motorcycles is NOT PERMITTED

Carry packages securely:

- in boot of car, or
- away from driver in vans and station wagons, and
- segregated from non-compatible dangerous Goods

Do not leave packages unsecured at ANY time

For general radiation advice contact
Radiation Control Section
Environment Protection Authority
Department of Environment and Conservation
Telephone: 9995 5959 (business hours).

In an Emergency, contact:
HAZMAT Team
Telephone: 000 (All hours)

APPENDIX 22.2 (cont.)

INFORMATION FOR CARRIERS

HANDLING RULES

Radioactive material (RAM) presented for transport is packaged in accordance with the IAEA Regulations which ensures that it is safe to handle under normal conditions.R Nevertheless, to prevent unnecessary exposure to radiation there are certain basic rules that should be followed as the radiation exposure received will depend on how long and how close a person remains near packages containing RAM. To minimise radiation exposure:

- Contact time with the package should be kept short.
- RAM packages should be handled without delay — keep it moving.
- No-one should stand around, sit near or sit on a RAM package.
- Time consuming tasks, such as paperwork, should not be carried out near a RAM package.
- All personnel should be kept as far away as practicable from packages containing RAM.
- RAM packages should be stored well away from offices, rest rooms and occupied work areas.
- When transporting RAM packages any long distance, the vehicle used should allow the driver to maintain a distance of at least a metre or more from the packages.
- AM packages should be secured so that they will not move during transport — small, light packages should be stored in a basket while larger, heavy packages should be properly blocked and braced.
- RAM packages must not be stored in the one location with transport indexes that add up to more than 50. (The transport index is written on the Yellow Category II or Category III label.)

DANGEROUS GOODS CLASS LOADING RESTRICTIONS FOR ROAD AND RAIL

(UN Recommendations on the Transport of Dangerous Goods – Model Regulations Eighteenth revised edition)

(1) The requirements of this clause are additional to those of the Australian Code for the Safe Transport of Radioactive Material in relation to the compatibility of radioactive material with other dangerous goods, food, undeveloped photographic film and personnel.

(2) Radioactive material must be segregated from other incompatible dangerous goods so as to minimise hazards in the event of accidental leakage, spillage or other accident.

(3) Whenever other dangerous goods are stowed with radioactive material, the most stringent segregation provisions for any of the goods apply

UN NUMBER	PROPER SHIPPING NAME and description
2908	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE — EMPTY PACKAGING
2909	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – ARTICLES MANUFACTURED FROM NATURAL URANIUM or DEPLETED URANIUM or NATURAL THORIUM
2910	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – LIMITED QUANTITY OF MATERIAL
2911	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE – INSTRUMENTS or ARTICLES
3507	URANIUM HEXAFLUORIDE, RADIOACTIVE MATERIAL, EXCEPTED PACKAGE, less than 0.1 kg per package, non-fissile or fissile-excepted*
2912	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non fissile or fissile-excepted*
3321	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II) non fissile or fissile- excepted*
3322	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III) non fissile or fissile-excepted*
3324	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), FISSILE
3325	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III), FISSILE
2913	RADIOACTIVE MATERIAL, SURFACE CONTAMI-ATED OBJECTS (SCO-I, SCO-II or SCO-III) non fissile or fissile-excepted*
3326	RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I or SCO-II), FISSILE
2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE, non-special form, non fissile or fissile-excepted *
3327	RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSILE non-special form
3332	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, non fissile or fissile-excepted*
3333	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, FISSILE
2916	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE, non fissile or fissile-excepted*
3328	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE, FISSILE
2917	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE, non fissile or fissile-excepted*
3329	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE, FISSILE
3323	RADIOACTIVE MATERIAL, TYPE C PACKAGE, non fissile or fissile-excepted*
3330	RADIOACTIVE MATERIAL, TYPE C PACKAGE, FISSILE
2919	RADIOACTIVE MATERIAL, TRANSPORTED UNDER SPECIAL ARRANGEMENT, non fissile or fissile-excepted *
3331	RADIOACTIVE MATERIAL, TRANSPORTED UNDER SPECIAL ARRANGEMENT, FISSILE
2977	RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, FISSILE
2978	RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE non fissile or fissile-excepted*

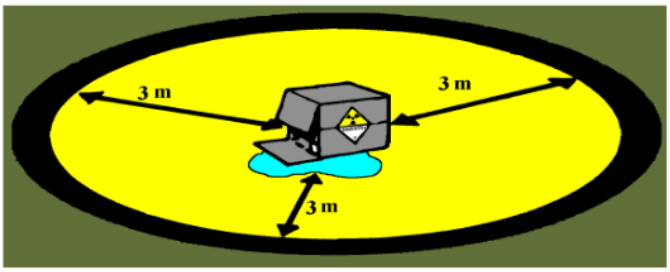
* The “PROPER SHIPPING NAME” is found in the column “PROPER SHIPPING NAME and description” and is restricted to that part shown in CAPITAL LETTERS. In the cases of UN 2909, UN 2911, UN 2913 and UN 3326, where alternative proper shipping names are separated by the word “or”, only the relevant proper shipping name shall be used.

* The term “fissile-excepted” refers only to material excepted under para. 417

IN CASE OF ACCIDENT

If a RAM package has been damaged, and you suspect that the damage may allow leakage of radiation or spillage of radioactive material:

- Stay away from the package and do not touch it.
- Keep other people away from it.



- Notify your supervisor or manager, also inform them of any person who might have been contaminated — they will call for expert technical help if necessary.
- Tell anybody who might have touched the damaged package to report to the supervisor or manager — they will arrange the necessary action.
- Wash your hands thoroughly if you have touched the damaged package or objects near it and tell the supervisor or manager of your possible contamination by RAM.
- Have yourself checked for possible contamination before you leave work.
- Note any vehicles involved in the accident — the vehicles should remain at the accident site until cleared by the police or a competent person.
- Do not eat or smoke or drink or leave until checked for possible contamination.
- Advise the competent authority of details of the accident as soon as possible and follow any instructions subsequently issued.

EMERGENCIES:

AFTER HOURS CONTACT POLICE OR FIRE BRIGADE

AUSTRALIAN COMPETENT AUTHORITIES FOR THE TRANSPORT OF RADIOACTIVE MATERIAL BY ROAD/RAIL/INLAND WATERWAYS

COMMONWEALTH STATE / TERRITORY	CONTACT	COMPETENT AUTHORITY
Commonwealth	Chief Executive Officer ARPANSA PO Box 655 Miranda NSW 1490 Tel: (02) 9541 8333 Fax: (02) 9541 8314 Email: info@arpansa.gov.au	Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)
Australian Capital Territory	Director, Environment and Radiation Safety Health Protection Service ACT Health Directorate Locked Bag 5005 Weston Creek ACT 2611 Tel: (02) 5124 9700 Fax: (02) 5124 5554 Email: hps@act.gov.au	Australian Capital Territory Radiation Council
New South Wales	Manager Hazardous Materials, Chemicals and Radiation Environment Protection Authority PO Box A290 Sydney South NSW 1232 Tel: (02) 9995 5959 Fax: (02) 9995 6603 Email: radiation@epa.nsw.gov.au	Environment Protection Authority
Northern Territory (i) for radioactive ores and concentrates	Chief Inspector – Radioactive Ores and Concentrate (Packaging and Transport) NT WorkSafe GPO Box 1722 Darwin NT 0801 Tel: 1800 019 115 Email: ntworksafe@nt.gov.au	Work Health Authority
(ii) for all other radioactive substances	Manager Radiation Protection Radiation Protection Section Department of Health GPO Box 40596 Casuarina NT 0811 Tel: (08) 8922 7152 Fax: (08) 8922 7334 Email: envirohealth@nt.gov.au	Department of Health
Queensland	Director, Radiation Health Department of Health PO Box 2368 Fortitude Valley BC QLD 4006 Tel: (07) 3328 9310 Fax: (07) 3328 9622 Email: radiation_health@health.qld.gov.au	Department of Health
South Australia	Manager, Radiation Protection Environment Protection Authority GPO Box 2607 Adelaide SA 5001 Tel: (08) 8463 7826 Fax: (08) 8124 4671 Email: radiationprotection@epa.sa.gov.au	Minister for Sustainability, Environment and Conservation
Tasmania	Principal Health Physicist, Radiation Protection Unit Department of Health & Human Services GPO Box 125 Hobart TAS 7001 Tel: (03) 6222 7256 Fax: (03) 6222 7257 Email: radiation.protection@dhhs.tas.gov.au	Director of Public Health
Victoria	Team Leader, Radiation Safety Department of Health GPO Box 4541 Melbourne VIC 3001 Tel: 1300 767 469 Fax: 1300 769 274 Email: radiation.safety@health.vic.gov.au	Secretary, Department of Health
Western Australia	Secretary Radiological Council Locked Bag 2006 PO Nedlands WA 6009 Tel: (08) 9222 2000 Email: radiation.health@health.wa.gov.au	Radiological Council

APPENDIX 22.2 (cont.)

INSTRUCTIONS

The following instructions must be followed by all transporters carrying labelled packages of radioactive materials:		YES	NO
1.	Check that a Radioactive Goods (consignment) form is attached to each package and that it has been completed with details of each radioactive material being delivered, destination and name of the addressee		
2.	Check that a "Shipping Document" for each package is issued to the driver/transporter		
3.	There are three placard signs in this kit. Put one placard on each side of the vehicle and one on the rear of the vehicle.		
4.	Transport the three Emergency Road Hazard Signs that are in this kit for use in an emergency.		
5.	Transport packages securely either: • in the boot of a car; or • away from the driver of a van or station wagon, and • segregated as per ADG code from other incompatible Dangerous Goods		
6.	**Carry these instructions with you in the vehicle in the document holder.**		
7.	Carry the appropriate safety equipment (personal protective, spill, etc) that the estimated risk of the consignment, and any other relevant requirements, deem necessary (for example, a Type A package would have negligible risk and as such no equipment is required).		
8.	Carry a mobile phone to be used in the event of an accident.		
9.	At each destination deliver the appropriate package together with its consignment form, to the addressee or their agent who should be a licensee. Adjust any "shipping documents" accordingly.		
10.	At your last destination remove the three yellow transport placards from the outside of the vehicle and replace them in this kit. It is illegal to display Dangerous Goods signs if Dangerous Goods are not in or on the vehicle.		
11.	Passengers are not to be carried at the same time as packages containing radioactive material. However, a licensee responsible for the radioactive material being carried may travel in the vehicle, or if two or more people are required for radionuclide procedures off site, they may all travel in the same vehicle.		
12	The vehicle must not be left unattended when carrying packages containing radioactive substances, except when delivering a package to its consignee.		

APPENDIX 22.2 (cont.)

ACCIDENT ACTION

In the event of an accident, **DON'T PANIC**. The packaging complies with international standard requirements and is designed to withstand accidents. If the package is not severely damaged, the radioactive material is most unlikely to be damaged, and its container is unlikely to leak. **So attend first to the needs of any injured persons.**

If a road vehicle transporting radioactive materials is involved in an accident that results in a dangerous situation (injury, road hazard, escape/leakage of materials, fire, vehicle immobilised, etc), the driver of the vehicle must:

- Notify Emergency Services “000” (Police, Fire Brigade, Hazmat, Ambulance);
- Notify the Institute’s R.S.O. and/or the responsible head of department;
- Provide reasonable assistance to Emergency Services, or the responsible authority officer in charge.

In addition to the above, the routine in the event of such an accident is:

1. Leave vehicle (if possible) and assess the injury status of others involved in the accident;
2. At all times do not become another victim, if in doubt leave it to emergency services;
3. Assess the integrity of the radioactive packages, with minimal contact (or exposure);
4. With the results of the assessment in mind it may be necessary to complete the above actions of notification – i.e. notify Emergency Services, Institute’s HSW, etc;
5. If possible, gain the assistance of passers-by to keep onlookers and other traffic at a safe reasonable distance;
6. Use the Emergency Road Hazard signs (three of these are to be carried in the vehicle at all times that radioactive materials are being transported – see APPENDIX 3 attachment for representation of sign);
7. Inform Emergency Services of any Environmental or Human hazards (fire, spill, etc);
8. Wait for and assist emergency services.

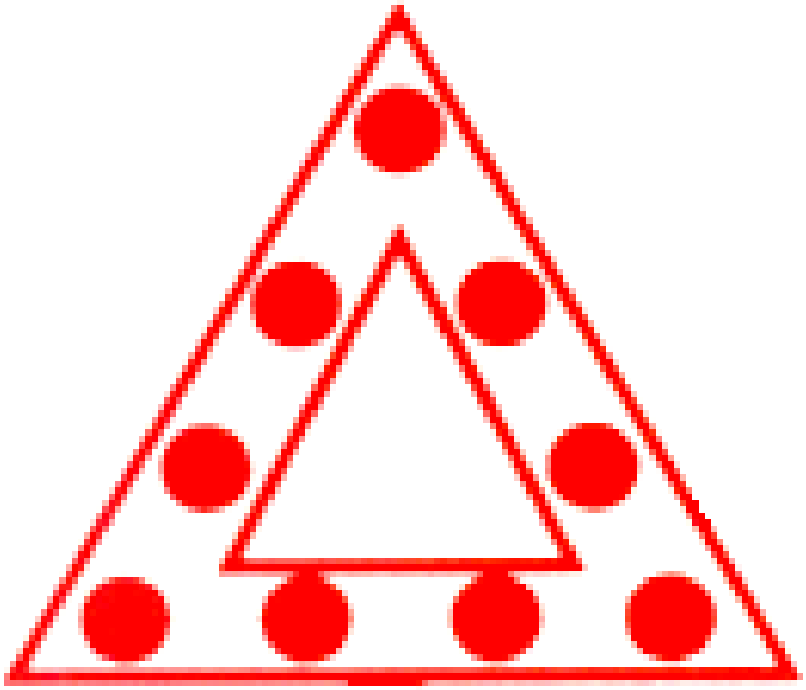
Other than that, if there is no risk from the radioactive materials leaking, or the packages are undamaged then the following applies:

- If the damage sustained by the vehicle does not have to be reported to the police and the vehicle can still be driven, deliver the parcel to the addressee, and tell them that the vehicle was involved in a minor accident on the way. Give a detailed report to the HSW.

APPENDIX 22.3

The Road Hazard Sign

These are to be carried in the vehicle and used any time the vehicle is involved in an accident or becomes immobilised (breakdown, etc). These signs are to comply with Australian Standard AS3790.



INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Safety with Lasers
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S23
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Laser Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Laser Safety, Laser Devices, Lasers
SUMMARY *Brief summary of the contents of the document*	Safety and management of Lasers and Laser devices.

INDEX – Section 23

1. BACKGROUND

Lasers can cause severe damage to the eyes and skin. Ocular damage during laser use is of particular concern, and therefore laser products are classified based on the maximum level of laser radiation that is accessible during normal operation. In increasing order of ocular hazard, the classes are: Class 1, "*Class 1C*", Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4.

All Class 3B and Class 4 lasers must be registered with HSW. This includes Class 1 laser systems that have incorporated within them Class 3B or Class 4 lasers except manufactured Class 1 laser systems where human access to the radiation is impossible during a normal operation and the system is on a service contract with the manufacturer/supplier for installation, maintenance and service.

The University also has an overarching Laser Safety Reference Document (under development), which should be consulted by those intending to use lasers. This will assist in preparation for establishing the facility and development of SOPs.

Note: In Australia, a number of standards apply to laser products:

- AS/NZS IEC 60825.1:2014: Safety of laser products - Equipment classification and requirements
- AS/NZS IEC 60825.2:2011: Safety of laser products - Safety of optical fibre communication systems (OFCS)
- AS/NZS IEC 60825.14:2011: Safety of laser products - A user's guide.
- AS/NZ 4173 (2020): Guide to the Safe Use of Lasers in Health Care.

Definitions:

- Maximum permissible exposure (MPE): the level of laser radiation to which persons may be exposed without suffering adverse effects.
- Nominal ocular hazard distance NOHD: the maximum distance from the output aperture where the beam is above the ocular MPE.
- Nominal ocular hazard area NOHA

2.0 RESPONSIBILITIES

NOTE: This section excludes optical drives (e.g. CD and DVD drives) and most laser pointers

2.1 Associate Director, Employee Relations and Work, Health and Safety

Maintains an inventory of laser facilities, equipment, users and their eye health records

The following details about the laser are required:

(a) Manufacturer's details

(b) Model & Serial Number

(c)Laser type(s) and rated power

(d) Enclosed or open

(e) Storage/usage location

(f) Date and nature of modifications to a laser and its associated checking and classification

2.2 Chief Investigators/Responsible Academics

Chief investigators/Responsible Academics that are responsible for projects and procedures that involve class 3B and Class 4 lasers must:

- Must ensure at a minimum that all class 3B, 4 and class 1 embedded 3B or 4 lasers (except manufactured Class 1 laser systems where human access to the radiation is impossible during a normal operation and the system is on a service contract with the manufacturer/supplier for installation, maintenance and service) have been registered with the LSO/HSW (link to registration form)
- ensure compliance with current standards and codes of practice regarding operation and maintenance of lasers and the facilities in which they are located
- ensure that the project has been approved by the CRTC (through the safety review process) before commencing work
- ensure that others involved with the project or procedure have been trained to be competent to operate the laser or if they are not deemed competent (they must have been trained) are supervised by someone who has been trained and is competent to operate the laser. Records of training must be maintained.
- ensure that those trained to operate the laser have completed a University of Newcastle Health and Hazard Assessment Questionnaire (HHAQ) identifying work with lasers and ensure the operators attend appointments for eye-tests at the required intervals. These eye testing records are maintained by the University of Newcastle Health Service and made available toHSW and will be kept for 30 years.
- ensure that records of laser maintenance and laser facility maintenance are kept in a written form (could be electronic) and stored for 30 years.
- inform and obtain permission from the laser safety officer or their delegate before disposing of a laser or decommissioning of a laser or its facility
- ensure that personnel involved with the project or procedure wear personal protective equipment (PPE), appropriate to the hazard including Australian Standard approved eyewear where identified as necessary.

2.3 Users of class 3B and Class 4 lasers

Users of class 3B and Class 4 lasers (excluding optical drives but including class 1 that enclose class 3R, 3B, & 4) must:

- only use the laser or the facility to the extent of the scope of their documented training and competency
- only use the laser or facility beyond the scope of their documented competency but within their training when under the direct supervision of a person who has been trained and is competent at that level of usage
- wear any PPE identified as necessary for the use of the laser
- have eyes tested if and as required by the University

2.4 The laser safety officer of the University (LSO)

The Laser Safety Officer of the University (LSO) (or RSO where one is not available) must:

- must provide advice about the installation, servicing, decommissioning, use and training with regards to lasers and laser facilities in the university.
- must provide reports on a needs be basis to the HSW unit, the CRTC, and the DVC (R&I)
- be a contact point for questions about Laser safety issues
- work with the HSW to audit laser facilities
- must actively provide advice to the university on changes to legislation, guidelines and standards regarding lasers and laser facilities
- must ensure that lasers built or modified and operated at the University or University controlled premises are checked and their classification confirmed.

3.0 ADMINISTRATIVE ARRANGEMENTS

Lasers used in the University are governed by the guidelines (refer to the Laser Safety Reference document) summarized in this document as approved by the Health and Safety team and the appointed Laser Safety Officer (LSO). Administrative arrangements and responsibilities are specified in the Laser Safety Reference document and encompass the following:

- Reading and becoming familiar with the contents of the Laser Safety Reference document and relevant Australian/New Zealand Standards.
- Reading safety instructions in relevant laser equipment operator's manuals and respective laboratory administrative, alignment and Safe Operating Practice while using and operating lasers. Familiarised yourself with all other aspects of the laser requirements and laboratory safety as directed by the LSO or Supervisor.
- Undertaking a risk assessment for the work to be performed and keeping the supervisor fully informed of any departure from established safety procedures. This includes

notification of any accident or exposure incident immediately to a supervisor and completing a report using the University of Newcastle incident reporting system.

- Obtaining required safety approvals and maintaining identified records

3.1 USAGE OF LASERS (CLASSES 3R, 3B, & 4))

For establishing new laser facilities and using non-enclosed class 3R, 3B and 4 lasers, project safety applications must be approved by the CRTC before any work can take place.

LSO consultation and sign off by LSO and HSW.

3.2 RISK ASSESSMENT

All operators undertaking experiments involving Class 3B or Class 4 lasers must undertake a risk assessment of the procedure/process/experiment prior to starting the work. The risk assessment must be part of the project safety approval form that is to go to the HSW and CRTC before a project may commence.

In the case of undergraduate students, undergraduate lab managers and/or student supervisors will undertake a risk assessment of all experiments involving lasers and provide SOPs to all students undertaking these respective experiments. Undergraduate practical sessions involving lasers should be approved by the CRTC through the safety review process when they are first developed and if any modification is made that changes the risk profile.

4.0 DOCUMENTATION

Records of Laser Equipment.

Records of Approved Laser Users/Operators.

Records of Service, inspection and calibration

5.0 AUDIT

Every 2 years

6.0 REFERENCES

See Part 1 of this section

7.0 REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Sept., 2015	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
June 2018	Revision 7	Melissa Musicka & William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Melissa Musicka & William Bartolo

INTERNAL ONLY

RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	Safety with UV Radiation
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Procedure
DOCUMENT NUMBER	RMP-S24
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	University of Newcastle Radiation Safety Manual
EXECUTIVE SPONSOR or EXECUTIVE CLINICAL SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service bartolo-safety@hotkey.net.au
KEY TERMS	Radiation safety, Ultraviolet, transilluminators
SUMMARY *Brief summary of the contents of the document*	Procedures for the safe use of UV apparatus

INDEX – Section 24

1. BACKGROUND

UV radiation is invisible to the eye and it is non-ionizing form of radiation in the 100 nm to 400 nm wavelength region of the electromagnetic spectrum. UV radiation is arbitrarily divided into UV-A (315 nm to 400 nm), UV-B (280 nm to 315 nm), and UV-C (100 nm to 280 nm). UV lasers are not covered in this section; please refer to the laser safety section for safety issues related to lasers.

The ability of UV radiation to penetrate human tissue depends on wavelength. UV-A is the most penetrating among the UV groups and it can cause skin damage and cataract formation. UV-B is the most destructive form of UV and it can cause erythema (sunburn) and corneal burn. The UV-B erythema threshold is 1,000 times lower than the erythema threshold of the UV-A, and it is much more effective in causing damage to live tissue then UV-A. UV-C cannot penetrate the dead layer of human skin; however, it can produce corneal burn. UV-C kills bacteria and it is used in germicidal lamps. Therefore if any research projects involve the use or exposure to UV, special attention to this needs to be made this in the risk assessments. For outdoor natural exposures to UV, refer to university policies Sun Protection Guidelines for Outdoor Workers and Sun Protection Policy.

ARPANSA RPS12 Tables 1 and 2 are in Appendix 24.1 attached to this section.

2. RESPONSIBILITIES

2.1. The Technical manager or equivalent of the facility

The technical manager (or equivalent) of the facility will be responsible for monitoring and providing advice on UV safety within laboratories. The Technical manager will have the authority to make immediate adjustments to procedures, or to immediately require a procedure to cease, or to shut down a facility.

2.2. The Radiation Safety Officer

Will provide a consultative role as required

2.3. Chief Investigator/Responsible Academic

The Chief Investigator/Responsible Academic is responsible for ensuring that all projects involving UV have an approved risk assessment, that all procedures are performed safely, and personnel working on the project are appropriately trained.

2.4. Personnel working on the project

Personnel working on the project will perform all procedures such that risk from UV exposure is minimised.

3.0 UV RADIATION EXPOSURE GUIDELINES

The university expects protection when using UV apparatus such that there are no direct exposed surfaces of the body with particular attention to protecting the eyes ARPANSA Radiation Protection Series No. 12 **Occupational Exposure to Ultraviolet Radiation** and the associated supplementary documents in which safety recommendations and limits are given is the recommended reference for further information.

3.1 UV Control Measures

A risk assessment will be carried out and approved to ensure that appropriate control measures can be implemented to prevent UV exposure. Control measures should not create other safety hazards.

NOTE: Personal Protective Equipment - PPE is the last stage in protection from UV and should be used in conjunction with engineering and administrative controls. Commonly used PPE against UV are Polycarbonate UV safety goggles, Polycarbonate UV face shields, long-sleeved, tightly-woven clothing that covers much of the body, and gloves. Application of sun-screen with high sun-protection factor (>15) against UV-A and UV-B may provide some protection. However, the use of UV skin blocks is considered inadequate for protection against the high irradiance of man-made UV radiation sources.

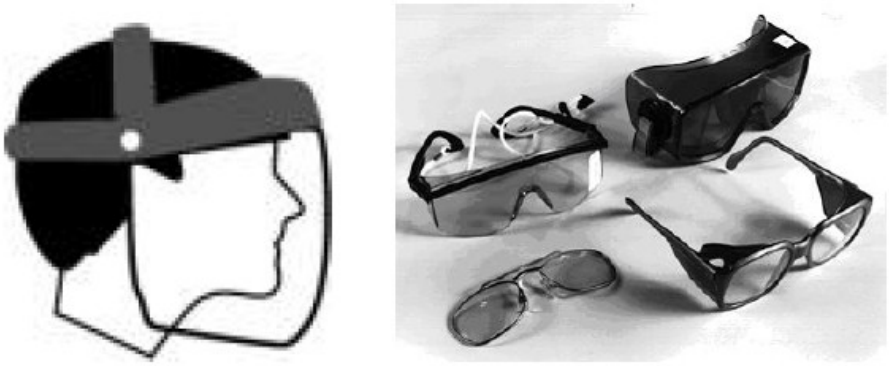


Figure 24.1. *UV personal protective equipment*

Protective eyewear must comply with Australian Standard ASAS/NZS 1067.1 and AS 1337 as a minimum.

3.2 Equipment And Area Label

Any equipment that emits UV radiation and the area where the equipment is located must have appropriate UV warning labels posted (see fig. 24.2). There is no standard UV warning label.

Figure 24.2. *UV warning signs*

3.3 Training and Supervision

Workers who may be exposed to ultraviolet radiation must be trained in safe work practices regarding ultraviolet radiation and supervised when appropriate. They must also be trained about the controls in place to manage the potential ultraviolet radiation hazard. Management must maintain records of such staff training. There must be appropriate procedures in place, developed as part of a plan for the control of exposure to ultraviolet radiation, to ensure that the safe systems of work designed to prevent ultraviolet radiation exposure are utilised.

4.0 DOCUMENTATION

The following documentation is required to be kept in the facility and records maintained for a minimum of 5 years:

- UV Equipment Log Book
- UV User and Training Record

5.0 AUDIT

All UV incidents are to be reported to HSW and these are to be tabled and discussed at the CRTC.

6.0 REFERENCES

ARPANSA. Occupational Exposure to Ultraviolet Radiation. RPS Publication No. 12. December 2006

ARPANSA. Management Plan for Artificial Sources.

Standards Australia, *AS 1337: Eye Protectors for Industrial Applications* (1992).

Standards Australia, *AS 1067.2*: *Sunglasses and Fashion Spectacles - Performance Requirements* (1990).

Standards Australia, *AS 1067.1: Sunglasses and Fashion Spectacles - Safety Requirements* (1990).

Standards Australia, *AS 2604: Sunscreen Products - Evaluation and Classification* (1998).

Standards Australia, AS 4399: *Sun Protective Clothing - Evaluation and Classification*

7.0 REVISION AND APPROVAL HISTORY *(state the author of the document, the date it was written, its revision number and approval history)*

Date	Revision No.	Author and Approval
Mar., 2015	draft	William Bartolo, Bartolo Safety Management Service
March, 2016	Draft 3	William Bartolo, Bartolo Safety Management Service
Nov, 2016	Draft 4	William Bartolo, Bartolo Safety Management Service
April, 2017	Revision 5	William Bartolo, Bartolo Safety Management Service
May, 2019	Revision 8	Ms Melissa Musicka & William Bartolo
Nov., 2021	Revision 9	Ms Melissa Musicka & William Bartolo

Appendix 24.1 ARPANSA Schedule 1 Tables

Table 1: Ultraviolet radiation exposure limits and Relative Spectral Effectiveness

Wavelength[a] (nm)	Exposure Limit ($J.m^{-2}$)	Exposure Limit ($mJ.cm^{-2}$)	Relative Spectral Effectiveness S_λ
180	2 500	250	0.012
190	1 600	160	0.019
200	1 000	100	0.030
205	590	59	0.051
210	400	40	0.075
215	320	32	0.095
220	250	25	0.120
225	200	20	0.150
230	160	16	0.190
235	130	13	0.240
240	100	10	0.300
245	83	8.3	0.360
250	70	7.0	0.430
254[b]	60	6.0	0.500
255	58	5.8	0.520
260	46	4.6	0.650
265	37	3.7	0.810
270	30	3.0	1.000
275	31	3.1	0.960
280[b]	34	3.4	0.880
285	39	3.9	0.770
290	47	4.7	0.640
295	56	5.6	0.540
297[b]	65	6.5	0.460
300	100	10	0.300
303[b]	250	25	0.120
305	500	50	0.060
308	1 200	120	0.026
310	2 000	200	0.015
313[b]	5 000	500	0.006

Table 1: Ultraviolet radiation exposure limits and Relative Spectral Effectiveness (continued)

Wavelength[a] (nm)	Exposure Limit ($J.m^{-2}$)	Exposure Limit ($mJ.cm^{-2}$)	Relative Spectral Effectiveness S_λ
315	1.0×10^4	1.0×10^3	0.003
316	1.3×10^4	1.3×10^3	0.0024
317	1.5×10^4	1.5×10^3	0.0020
318	1.9×10^4	1.9×10^3	0.0016
319	2.5×10^4	2.5×10^3	0.0012
320	2.9×10^4	2.9×10^3	0.0010
322	4.5×10^4	4.5×10^3	0.00067
323	5.6×10^4	5.6×10^3	0.00054
325	6.0×10^4	6.0×10^3	0.00050
328	6.8×10^4	6.8×10^3	0.00044
330	7.3×10^4	7.3×10^3	0.00041
333	8.1×10^4	8.1×10^3	0.00037
335	8.8×10^4	8.8×10^3	0.00034
340	1.1×10^5	1.1×10^4	0.00028
345	1.3×10^5	1.3×10^4	0.00024
350	1.5×10^5	1.5×10^4	0.00020
355	1.9×10^5	1.9×10^4	0.00016
360	2.3×10^5	2.3×10^4	0.00013
365[b]	2.7×10^5	2.7×10^4	0.00011
370	3.2×10^5	3.2×10^4	0.000093
375	3.9×10^5	3.9×10^4	0.000077
380	4.7×10^5	4.7×10^4	0.000064
385	5.7×10^5	5.7×10^4	0.000053
390	6.8×10^5	6.8×10^4	0.000044
395	8.3×10^5	8.3×10^4	0.000036
400	1.0×10^6	1.0×10^5	0.000030

[a] Wavelengths chosen are representative; other values should be interpolated at intermediate wavelengths.

[b] Emission lines of a mercury discharge spectrum.

Table 2: Limiting UV exposure durations based on EL

Duration of Exposure Per Day	Effective Irradiance E_{eff} ($W.m^{-2}$)	Effective Irradiance E_{eff} ($\mu W.cm^{-2}$)
8 Hr	0.001	0.1
4 Hr	0.002	0.2
2 Hr	0.004	0.4
1 Hr	0.008	0.8
30 Min	0.017	1.7
15 Min	0.033	3.3
10 Min	0.05	5
5 Min	0.1	10
1 Min	0.5	50
30 Sec	1.0	100
10 Sec	3.0	300
1 Sec	30	3 000
0.5 Sec	60	6 000
0.1 Sec	300	30 000

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RADIATION MANAGEMENT PLAN COVER SHEET

NAME OF DOCUMENT	RMP Attachment – University of Newcastle RML Example
TYPE OF DOCUMENT *Policy, Procedure or Clinical Guideline*	Background Information for Radiation Users
DOCUMENT NUMBER	RMP-Attachment
DATE OF PUBLICATION	
RISK RATING	
LEVEL OF EVIDENCE	
REVIEW DATE *Documents are to be reviewed a maximum of five years from date of issue*	
FORMER REFERENCE(S) *Documents that are replaced by this one*	
EXECUTIVE SPONSOR	Radiation Management Licence Holder, Deputy Vice Chancellor Research and Innovation Division
AUTHOR *Position responsible for the document including email address*	Mr William Bartolo – University of Newcastle Consultant RPA [RSO] Bartolo Safety Management Service
KEY TERMS	License
SUMMARY *Brief summary of the contents of the document*	Example of RML for 2018

This is an example of the University of Newcastle Radiation Management License

It is the 2018 version of the license and is replaced every year and updated as necessary.

Some details may be incorrect at the time of reading.

Regulated Material Pages have been omitted.

Some material has been redacted for security purposes.

Radiation Control Act 1990

Radiation Management Licence

THE UNIVERSITY OF NEWCASTLE
Deputy Vice Chancellor (Research & Innovation)
The Chancellery, University Drive
CALLAGHAN NSW 2308

Contact: Melissa Musicka

LICENCE DETAILS

Licence number: [redacted] Expiry date: **28 Dec 2018**

Old licence number: [redacted]

Licence type: Sell, possess, store or give away regulated material (including radiation apparatus, radioactive substances or items containing radioactive substances) for 1 year

Subject to the renewal of the licence before the expiry date and to any condition(s) endorsed hereunder, THE UNIVERSITY OF NEWCASTLE is hereby licensed under the Radiation Control Act, 1990 by the Environment Protection Authority. The regulated material(s) listed in the attached schedule are included in this licence. The conditions of this licence are attached. Separate to the requirements of this licence, general obligations of licensees are set out in the Radiation Control Act ("the Act"), the Regulations made under the Act and any Codes of Practice referred to therein.

The licence holder can apply to vary the conditions of this licence. An application form for this purpose is available from the EPA. The EPA may also vary the conditions of the licence at any time by written notice without an application being made.

The licensee is responsible for the renewal of this licence before the expiry date and for ensuring that the mailing address is current. Penalties apply for using or selling regulated material without holding a current and appropriate licence.

This licence will remain in force until it expires or is surrendered by the licence holder or until it is suspended or revoked by the EPA. A licence may only be surrendered with the written approval of the EPA.

Team Leader Chemicals and Radiation Licensing
Environment Protection Authority NSW

Licence Conditions

1. General

1.1. These conditions apply in addition to the obligations that a person responsible for regulated material has under the Act and Regulation

1.2. The licensee commits an offence and may be subject to penalties if the licensee fails to comply with these conditions

1.3. The licensee is authorised to own, store, sell or give away regulated material only to the extent specified by the licence type

1.4 The licensee must ensure that all regulated material in the form of ionising radiation apparatus, sealed source devices and all sealed sources for which they are the person responsible is detailed in this licence in accordance with the timeframes specified in Condition 7.

1.5. The licensee must ensure that all premises where unsealed radioactive substances are used or stored for which the licensee is the person responsible are detailed on this licence within seven days of commencing use or storage in a premises by completing the form published by the Authority and returning the form as instructed.

1.6 The regulated material detailed in this licence must only be used for the purpose(s) specified in this licence.

1.7. The licensee must notify the Authority within 14 days in writing of any change of the following information:

1.7.1. the registered office address of the licensee

1.7.2. the contact person for licence inquiries delegated by the licensee

1.7.3. the site contact person nominated by the licensee (where applicable)

1.8. All notifications required by these conditions must be sent to:

The Manager
Hazardous Materials, Chemicals and Radiation Section
NSW Environment Protection Authority
Department of Premier and Cabinet
PO Box A290
SYDNEY SOUTH NSW 1232

Or a PDF file may be sent to radiation@epa.nsw.gov.au

2. Safety information - radioactive substances

2.1. The licensee must ensure that a notice is displayed near to the radiation warning sign at the entrance to the premises (room, store, laboratory) where radioactive substances are kept or used that includes the following information:

2.1.1. the licensee's name,

2.1.2. the licence number,

2.1.3. the name and telephone number of the licensee's contact in the event of an emergency affecting the premises, and

2.1.4. the emergency service and telephone number to call in the event of an emergency affecting the premises.

2.2. The licensee must ensure that a summary of procedures relating to the safe use of a radioactive source is displayed at the premises where the regulated material is kept.

2.3. The licensee must ensure that detailed procedures to be followed in the event of a radiation accident are kept at the premises

3. Compliance certification - general

3.1. The licensee must ensure that diagnostic imaging apparatus and sealed source devices which are fixed radiation gauges, referred to in Conditions 4 and 5 of the Management Licence Conditions remain under an unbroken state of compliance certification during the transition from the requirements of the Radiation Control Regulation 2003 to the Radiation Control Regulation 2013.

4. Compliance certification - diagnostic imaging apparatus

4.1. The licensee must ensure that diagnostic imaging apparatus of the type listed in Column 1 of Table 1 for which the licensee is responsible, is certified by a consulting radiation expert accredited by the Authority as complying with the requirements for registration in Schedule 1 of the corresponding Part of Radiation

Guideline 6 - Registration requirements & industry best practice for ionising radiation apparatus used in diagnostic imaging, NSW EPA March 2004 (listed in Column 2 of Table 1), as published by the Authority from time to time:

4.1.1. before the apparatus is used, or

4.1.2. within two years of the anniversary of initial compliance certification - for mammography apparatus, fluoroscopy apparatus, computed tomography apparatus, and for apparatus that may be used for both fluoroscopy and radiography, or

4.1.3. within five years of initial certification - for dental radiography apparatus, radiography apparatus, and bone mineral density apparatus, or

4.1.4. if modifications have been made that affect the compliance of the apparatus with the requirements of Schedule 1 of the relevant Guideline, or

4.1.5. if the apparatus has been relocated and reassembled, or

4.1.6. where the purpose for which the apparatus is used has changed, or

4.1.7. in addition, in the case of mammography apparatus, an annual certificate is required in relation to mean glandular dose requirements or following any service or modification that may affect patient dose.

Table 1	
Column 1	Column 2
Apparatus for mammography	The requirements specified in Schedule 1, Part 1 Mammography
Apparatus for fluoroscopy or radiography	The requirements specified in Schedule 1, Part 2 Fluoroscopy and radiography
Apparatus for dental diagnostic purposes	The requirements specified in Schedule 1, Part 3 Dentistry (including maxillofacial)
Apparatus for veterinary purposes	The requirements specified in Schedule 1, Part 4 Veterinary science
Apparatus for computed tomography or bone mineral densitometry	The requirements specified in Schedule 1, Part 5, Computed tomography and bone mineral densitometry

4.2. If a consulting radiation expert certifies that radiation apparatus generally complies with mandatory requirements, but has specified that minor repairs are necessary so that the requirements of Schedule 1 of the relevant Part of Guideline 6 are met, the licensee must:

4.2.1. ensure that these repairs are carried out within the timeframe specified by the consulting radiation expert, and

4.2.2. adhere to any restrictions on the use or operation of the apparatus specified by the consulting radiation expert until the repairs have been carried out.

5. Compliance certification - fixed radiation gauges

5.1. The licensee must ensure that a sealed source device which is a fixed radiation gauge for which the licensee is the person responsible is certified compliant by a consulting radiation expert accredited by the Authority with the mandatory requirements published by the Authority:

5.1.1. before it is used, and

5.1.2. every two years before the anniversary of its initial compliance certification

6. Working life of sealed radioactive sources

6.1. The licensee must ensure that a sealed radioactive source for which the licensee is the person responsible is not used:

6.1.1. beyond the manufacturer's recommended working life for the source, or

6.1.2. if the manufacturer has not recommended the working life of the source, beyond 15 years after the date of manufacture of the source, or

6.1.3. unless the Authority has approved the use of the source for a further period and the licensee complies with any conditions for continued use set down by the Authority.

7. Notification of receipt and transfer of regulated material

7.1. The licensee must notify the Authority of the receipt or transfer of possession of regulated material (whether by sale or giving away) within seven days of receipt or transfer occurring, by completing the form published by the Authority and returning the form as instructed.

7.2. The licensee must notify the Authority within seven days if fixed radiation apparatus for which the licensee if the person responsible is relocated.

Note: This provision (7.1) does not apply to radioactive substances that are not in sealed source form.

8. Consent to dispose of radiation apparatus

8.1. The licensee may dispose of radiation apparatus, for which the licensee is the person responsible, but only if:

8.1.1. The radiation apparatus has been rendered permanently inoperable, and

8.1.2. The licensee notifies the Authority within seven days using the approved form

9. Records

9.1. The following records must be kept in relation to regulated material for which the licensee is the person responsible:

9.1.1. Maintenance reports and summaries of quality assurance and / or wipe tests undertaken on any sealed radioactive source or sealed source device

9.1.2. Reports and certificates of compliance issued by a consulting radiation expert in relation to any radiation apparatus or fixed radiation gauge

9.1.3. The source certificate for any sealed radioactive source

9.1.4. Details of the type, location and movement of any radioactive substance(s)

9.1.5. Details of an annual stocktake of all radioactive substances kept or used

9.1.6. Details of all instances where the categories of regulated material used or kept change, as determined by Part 2, Cl.14 of the Regulation, and advise the EPA of any such change in writing within 14 days

9.2. The licensee must:

9.2.1. Maintain records in legible form or in a form that can be readily reproduced in a legible form,

9.2.2. Keep all records relating to regulated material for a period of two years after disposal, and

9.2.3. Provide all records relating to regulated material to the person to whom the regulated material is transferred, in the case of sale or giving away

10. Storage

10.1. Ensure that regulated material for which the licensee is responsible is safely and securely stored if it is not required for immediate use and that:

10.1.1. The store is constructed of durable materials

10.1.2. The store is lockable

10.1.3. Radiation levels in any accessible area outside the store do not exceed the dose limits for exposure in Schedule 5 of the Regulation

10.1.4. Any radioactive substances are not stored with explosives, combustible or corrosive materials

11. Whole body scanning

11.1. The licensee must ensure that computed tomography apparatus for which the licensee is responsible is not used for screening for early signs of illness in patients who have no symptoms or disease risk factors, except at the written request of an dependent medical practitioner and where the licensee has obtained the informed sent of the patient in writing.

Note: Informed consent requires that the patient has been informed of the scale of radiation dose from the procedure and the risks involved, including that persons under the age of 50 years are more at risk of developing cancers as a result of the procedure.

12. Cyclotron

12.1. The licensee must, prior to commencement of commissioning of the facility, submit a radiation protection plan to the Authority for its approval.

12.2. The licensee must, prior to commencement of normal operations, submit a copy of the acceptance test

documentation, providing certification that design features for hazard control are in place and operational, to the Authority for its approval.

12.3. The licensee must, if there is any variation to working procedures, engineering protective measures, or radiation monitoring plans, submit an amended radiation protection plan to the Authority for its approval.

12.4. The licensee must submit to the Authority a report on the operation of the cyclotron and ancillary facilities, as they relate to safety and radiation control issues for the first three months of its routine operation, and subsequently annually.

13. Guidelines

13.1. The licensee must comply with the obligations of 'responsible persons' in the following documents, to the extent that they apply to the licensee's radiation practice, as published by the New South Wales Environment Protection Authority (NSW EPA) http://www.epa.nsw.gov.au/radiation/radiationpubs.htm from time to time

13.1.1. Radiation Guideline 6 - Registration requirements & industry best practice for ionising radiation apparatus used in diagnostic imaging, NSW EPA March 2004:
Part 1: Mammography
Part 2: Fluoroscopy & radiography
Part 3: Dentistry (including maxillofacial)
Part 4: Veterinary science
Part 5: Computed tomography & bone mineral densitometry
Part 6: Test protocols for parts 2-5

Note: Appendix A of Guideline 6, Parts 2-5 Policy on x-ray protective clothing (2004) has been superseded by Policy on x-ray protective clothing, NSW EPA, Nov 2009.

14. Codes

14.1. The licensee must comply with the obligations of 'responsible persons' in the following documents, to the extent that they apply to the licensee's radiation practice, as published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) http://www.arpansa.gov.au/Publications/codes from time to time:

14.1.1. RPS 2. Code of Practice for the Safe Transport of Radioactive Material, ARPANSA Jan 2008

14.1.2. RPS 5. Code of Practice and Safety Guide for Portable Density/Moisture Gauges containing Radioactive Sources, ARPANSA, May 2004

14.1.3. RPS 8. Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes, ARPANSA, May 2005

14.1.4. RPS 10. Code of Practice and Safety Guide for Radiation Protection in Dentistry, ARPANSA, Dec 2005

14.1.5. RPS 13. Code of Practice and Safety Guide for Safe Use of Fixed Radiation Gauges, ARPANSA, Jan 2007

14.1.6. RPS 14. Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation, ARPANSA, May 2008

14.1.7. RPS 17. Code of Practice and Safety Guide for Radiation Protection in Veterinary Medicine, ARPANSA, July 2009

14.1.8. RPS 19. Code of Practice for Radiation Protection in the Application of Ionizing Radiation by Chiropractors, ARPANSA, Nov 2009

14.1.9. RHS 9. Code of practice for protection against ionizing radiation emitted from X-ray analysis equipment, ARPANSA, 1984

14.1.10. RHS 28. Code of practice for the safe use of sealed radioactive sources in bore-hole logging, ARPANSA, 1989

14.1.11. RHS 31. Code of practice for the safe use of industrial radiography equipment, ARPANSA, 1989

In the event of an inconsistency between the Codes and the current relevant NSW legislation, the requirements of the legislation prevail to the extent of the inconsistency.

15. Definitions

Person responsible has the same meaning as in section 6 of the Act

Act means the Radiation Control Act 1990 (http://www.epa.nsw.gov.au/legislation/ActSummaries.htm#radiation)

Diagnostic imaging apparatus means:

A. Any ionising radiation apparatus used or intended to be used for any medical diagnostic, veterinary diagnostic or dental purpose, or
B. Any ionising radiation apparatus used or intended to be used for radiotherapy or radiotherapy planning purposes.

Fixed radiation gauge means a sealed source device which is in a fixed position.

Regulation means the Radiation Control Regulation 2013 (http://www.epa.nsw.gov.au/legislation/RegulationSummaries.htm#RCreg)

Regulated material has the same meaning as in section 4 of the Act

Occupationally exposed has the same meaning as in clause 3 of the Regulation

Radiation accident has the same meaning as in clause 37 of the Regulation

Sealed source device has the same meaning as in section 4 of the Act.

Radiation Regulated Material (RRM) Schedule [redacted]

Location: Hunter Medical Research Institute - New Lambton Heights - Lot 1 Kookaburra Circuit, NEW LAMBTON HEIGHTS, NSW 2305

Radiation regulated material ID No [redacted] status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted] Radiation Waste Store	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group A	Radiation apparatus	General Radiography	Veterinary diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
37191	Control console / generator	Rad Source Technologies	Rad Source RS2000	3198	
37192	X-ray tube insert	Varian Medical Systems	-	40421-S2	
37234	X-ray tube housing	Varian Medical Systems	-	40421-S2	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Sealed source device	Other gauges	

Components:	Type	Manufacturer	Model No	Serial No	Source Name
37229	Container	Beckman Coulter	LS6500	7071417	

40789	Sealed source	Spectrum Techniques	27	iodine-129

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Bone Mineral Densitometry	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
46499	Control console / generator	General Electric	Prodigy	301645	
46500	X-ray tube housing	General Electric	8743	61298GR	
46501	X-ray tube insert	General Electric	BX-1L	34144	

Location: The University of Newcastle - CALLAGHAN - Hunter Building & ATC - Callaghan Campus, University Drive, CALLAGHAN, NSW 2308

Radiation regulated material ID No [redacted] status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
30473	X-ray tube housing	Philips Healthcare	989000086121	1576A208007	
30474	Control console / generator	Philips Healthcare	Optima 50	60112	
30475	X-ray tube insert	Philips Healthcare	989100085291	208007	

Radiation regulated material ID No [redacted] status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
30479	X-ray tube insert	Philips Healthcare	989100085291	208035	
30480	X-ray tube housing	Philips Healthcare	989000086121	18755A208035	
30481	Control console / generator	Philips Healthcare	Optima 50	601110	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
30484	X-ray tube insert	Philips Healthcare	989000085291	990497	
30485	X-ray tube housing	Philips Healthcare	R01648ROT350	10268A990497	
30486	Control console / generator	Philips Healthcare	Optimus	601971	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
30487	Control console / generator	Philips Healthcare	Optimus	60244	
30488	X-ray tube housing	Philips Healthcare	R01648ROT350	14886A206496	
30489	X-ray tube insert	Philips Healthcare	989000085291	206496	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Mammography	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
32746	Control console / generator	Siemens	Mammomat 300	01022S11	
32747	X-ray tube housing	Siemens	-	01543S06	
32748	X-ray tube insert	Siemens	-	01021S11	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Radiography / Fluoroscopy	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
37190	Control console / generator	VG Scientific (Thermo Fisher Scientific)	ESCA 3 253	7003	
37232	X-ray tube housing	VG Scientific (Thermo Fisher Scientific)	ESCA 3 253	7003	
37233	X-ray tube insert	VG Scientific (Thermo Fisher Scientific)	ESCA 3 253	7003	

Radiation Management Licence

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
42764	Control console / generator	Malvern Panalytical	Empyrean PW60XX	207009	
42765	X-ray tube insert	Malvern Panalytical	943003373105	DK410617	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
42766	Control console / generator	Malvern Panalytical	Epsilson 1 PW48XX/XX	DY0836	
42767	X-ray tube insert	Malvern Panalytical	DY0836	DY0836	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Radiography / Fluoroscopy	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
45073	Control console / generator	Philips Healthcare	4558-006-34391	15850027	
45074	X-ray tube housing	Philips Healthcare	989000086101	217577249020	
45075	X-ray tube insert	Philips Healthcare	989000070102	249020	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
Mobile electronic brachytherapy unit will be operated at two sites:- 1.[redacted]	Group B	Radiation apparatus	Kilovoltage Therapy X-Ray	Radiotherapy

Components:	Type	Manufacturer	Model No	Serial No	Source Name
45077	Control console / generator	Nucletron	XRF70P200/653	104044	
45078	X-ray tube insert	Nucletron	943078374021	DK409210	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Location: The University of Newcastle - CALLAGHAN - Aviation Building, University Drive, CALLAGHAN, NSW 2308

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
32749	Control console / generator	Philips Healthcare	PW3040/60	DY1663 0226	
32750	X-ray tube insert	Malvern Panalytical	Empyrean	DK403183	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
40671	Control console / generator	Malvern Panalytical	PW3040/60	DY3112	
40672	X-ray tube housing	UNKNOWN	0	0	
40673	X-ray tube insert	Empyrean	PW3040/60	DK410985	
41387	X-ray tube insert	Empyrean	PW3040/60	DK409272	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Cabinet x-ray/Inspection	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
41969	Control console / generator	Rigaku	micromax 007	ED318903	

Location: The University of Newcastle - CALLAGHAN - Callaghan Campus, University Drive, CALLAGHAN, NSW 2308

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Sealed source device	PET/SPECT Gamma Camera	

Components:	Type	Manufacturer	Model No	Serial No	Source Name
32751	Container	Philips Healthcare	C-PET	C057	
32752	Sealed source	Isotopes Product Laboratory		CZ-301	caesium-137

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Radiography / Fluoroscopy	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
32756	Control console / generator	Kodak	1118263	180-S0119	
32757	X-ray tube housing	Kodak	ASBXE17SW	0119077	

32758	X-ray tube insert	Kodak	--	3664/5180

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Sealed source device	Other gauges	

Components:	Type	Manufacturer	Model No	Serial No	Source Name
37227	Container	Leybold LD Didactic	Rutherford apparatus	experimental apparatus	
37228	Sealed source	Leybold LD Didactic		559820Z/AE-2286	americium-241

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Bone Mineral Densitometry	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
39102	Control console / generator	GE Healthcare (General Electric)	Lunar Prodigy Pro	300317	
39103	X-ray tube housing	Lunar	8743	69731	
39104	X-ray tube insert	Brand (Thermo Fisher Scientific)	BX-1L	56KO	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
39105	Control console / generator	TEL	58006405	6289	
39106	X-ray tube insert	TEL	581	58112803	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
39107	Control console / generator	TEL	58012807	6830	
39108	X-ray tube insert	TEL	581	58107403	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Bone Mineral Densitometry	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
40665	Control console / generator	GE Healthcare (General Electric)	Prodigy Acvance	500654GA	
40666	X-ray tube housing	GE Healthcare (General Electric)	8743	83019GA	
40667	X-ray tube insert	Brand (Thermo Fisher Scientific)	BX-1L	34518	

Radiation regulated material ID No[redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	X-RF/X-RD	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
41965	Control console / generator	Olympus Corporation	VMR-CCC-G2-A -XRF	800567	

Radiation regulated material ID No[redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Cabinet x-ray/Inspection	Analysis

Components:	Type	Manufacturer	Model No	Serial No	Source Name
45076	Control console / generator	Leybold LD Didactic	554800	MO 08481707	

Location: The University of Newcastle - CALLAGHAN - Campus, University Drive, CALLAGHAN, NSW 2308

Radiation regulated material ID No[redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Unsealed radioactive substance		Research laboratories – public facility

Components:	Type	Manufacturer	Model No	Serial No	Source Name

Radiation regulated material ID No[redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose

[redacted]	Group A	Radiation apparatus	General Radiography	Veterinary diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
40668	Control console / generator	GE Healthcare (General Electric)	2326480	78137WG7	
40669	X-ray tube housing	GE Healthcare (General Electric)	2216500-2	98959CX0	
40670	X-ray tube insert	GE Healthcare (General Electric)	2216450	165016GI7	

Location: The University of Newcastle - OURIMBAH - Central Coast Campus, OURIMBAH, NSW 2258

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group A	Radiation apparatus	Dental Radiography	Dental diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
10458	X-ray tube housing	Planmeca	Intra	ITHA51640	
10459	X-ray tube insert	Planmeca	D-0711-SB	92583	
10475	Control console / generator	Planmeca	Intra	IXRF059619	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group A	Radiation apparatus	Dental Radiography	Dental diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
10476	Control console / generator	Planmeca	Intra	IXRF59616	
10477	X-ray tube housing	Planmeca	Intra	ITHA51640	
10478	X-ray tube insert	Planmeca	D-0711-SB	92444	

Radiation regulated material ID No [redacted] status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Computed Tomography	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
21286	Control console / generator	Stratec	XCT-3000	91124	
21287	X-ray tube housing	Oberuber	802102B	6792	
21665	X-ray tube insert	Oxford Instruments	90503	48500	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Bone Mineral Densitometry	Non-medical analytical or educational

Components:	Type	Manufacturer	Model No	Serial No	Source Name
21196	X-ray tube insert	Hangzhou Wandong Electron Co	X862C	1021304A	
21288	Control console / generator	Hologic	Discovery	14143	
21289	X-ray tube housing	Hologic	010-0575	SQ-14779	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group A	Radiation apparatus	Panoramic Radiography	Dental diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
30490	X-ray tube housing	Sirona Dental Systems	5884999	06180	
30491	X-ray tube insert	Siemens	5934208	0360621	
30492	Control console / generator	Sirona Dental Systems	D3352	62341	

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group A	Radiation apparatus	Dental Radiography	Dental diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
37193	Control console / generator	Planmeca	PROX	IPX077429	
37194	X-ray tube housing	Planmeca	PROX	ITPX74030362	
37195	X-ray tube insert	Planmeca	D-0475B	3E53670	

Location: The University of Newcastle - Shortland - 70 Vale Street, SHORTLAND, NSW 2307

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	Radiography / Fluoroscopy	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
7685	X-ray tube insert	GE Healthcare (General Electric)	110/3DF	1103936	
8020	Control console / generator	GE Healthcare (General Electric)	Flexiview 8800	SA-0370358 6PU5	

8021	X-ray tube housing	GE Healthcare (General Electric)	2299888	388352GT5

Location: The University of Newcastle - TAMWORTH - Tamworth Education Centre, 114-148 Johnston Street, TAMWORTH, NSW 2340

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
40662	Control console / generator	GE Healthcare (General Electric)	AMX4 46-270157G1	263320WK4	
40663	X-ray tube housing	GE Healthcare (General Electric)	GE 46-155750G8	39445EC2	
40664	X-ray tube insert	GE Healthcare (General Electric)	GE 46-125686G8	242476TU0	

Location: The University of Newcastle - TAREE - Manning Education Centre, 69A High Street, TAREE, NSW 2430

Radiation regulated material ID No [redacted] (status Active)

Work Area	Fee Group	Type	Equipment	Purpose
[redacted]	Group B	Radiation apparatus	General Radiography	Medical diagnostic

Components:	Type	Manufacturer	Model No	Serial No	Source Name
40659	Control console / generator	GE Healthcare (General Electric)	AMX4 46-270157G1	258625WK3	
40660	X-ray tube housing	GE Healthcare (General Electric)	GE 46-155750G8	90856EC6	
40661	X-ray tube insert	GE Healthcare (General Electric)	GE 46-125686G8	4841TX3	