THE UNIVERSITY OF NEWCASTLE AUSTRALIA

# RADIATION
# SAFETY MANUAL

*ISSUED: JUNE 1995*
*REVISED: SEPTEMBER 2001*
*REVISED: JULY 2004*
*REVISED: OCTOBER 2004*
*REVISED: AUGUST 2009*
*REVISED: MARCH 2011*
*REVISED: OCTOBER 2012*
*REVISED: APRIL 2014*

# Radiation Safety Manual

## Section 1: Introduction

The Radiation Safety Manual is a very large document.

If you would like to suggest additional topics for the manual and any other comments or feedback designed to make it a more complete and/or user friendly document please email safetyclearance@newcastle.edu.au

Issued: June 1985
Revised: September 2001
Revised: July 2004
Revised: September 2004
Revised: August 2009 (2.9.2 Exemptions including addition of General Supervision definition)
Revised: March 2011
Revised: April 2014 – Section 4 Purchasing procedures

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# Radiation Safety Manual

## Section 1: Introduction

### 1.1 General

This manual is intended as a guide to those staff and students involved either directly or indirectly with the use of radioisotopes, ionising radiation and non-ionising radiation in research and teaching. The manual provides general information and guidelines on the recommended approaches to the use of radiation in research and teaching as well as information on some specific applications and regulations for the disposal of waste and emergency procedures.

The manual isn't a comprehensive guide on all aspects of the use of radiation and further specific information should be sought from the building Radiation Safety Officer or the University Radiation Safety Officer/Radiation Safety Advisor. Initial enquiries should be addressed to the Manager, Health and Safety Team, Human Resource Services.

This manual is designed for the user of radiation and any comments and/or criticisms will be carefully considered. Comments should be addressed to the University Radiation Safety Officer/Radiation Safety Advisor or the Manager, Health and Safety Team, Human Resource Services.

### 1.2 Acknowledgements

The University of Newcastle Occupational Health and Safety Committee wishes to acknowledge its indebtedness to the Newcastle Mater Misericordiae Hospital Radiation Safety Committee and Dr Tomas Kron for permission to reproduce several pages from the Radiation Safety Manual of the Newcastle Mater Misericordiae Hospital.

### 1.3 Philosophy

This University and the Occupational Health and Safety Committee is totally committed to the principle that underpins modern protection practice. With respect to radiation exposure that is to ensure at all times that 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 The University of Newcastle are expected to embrace this philosophy and in translate ALARA into their activities in relation to the use of radiation within their workplace and laboratories, to adhere to the content of this manual and to acknowledge their responsibilities to the general public, their fellow students, workmates and themselves.

# RADIATION SAFETY MANUAL

## Section 2: General Information

### Contents



## 2.1 Objectives of Radiation Protection

Radiation effects are divided into two groups:

- stochastic effects
- non-stochastic effects.

These terms are rather academic, but are not too difficult to understand.

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. Genetic effects are also stochastic.

With non-stochastic effects, there is a threshold and the severity of the effect is related to the dose. An example is a radiation burn - a small dose will not produce a burn, a very large dose will, and the larger the dose the worse the burn. The object of the radiation protection is to prevent detrimental non-stochastic effects, and to limit the occurrence of stochastic effects to acceptable levels.

This is achieved by setting annual limits to the radiation dose equivalent (not including natural or medical radiation) which can be received by workers and the general public. Also, there is a requirement that all uses of ionising radiation result in doses to patients, workers and public that is "As Low as Reasonably Achievable" - the ALARA principle. This means that we are to regard limits as just that, and aim for the lowest possible dose.

The dose limits and radiation protection are set by the International Commission on Radiological Protection (ICRP, 1990) (Refer Appendix) and are generally adopted by all countries.

## 2.2 Nature of Radiation Units

In this manual, reference will be made to the various types of radiation, and the units used for their measurement. SI units will be used throughout, however, in some areas old units will be given as well. A conversion table can be found in Appendix 3.

## Ionising Radiation

Ionisation may be simply defined as any process by which an atom or molecule gains an electric charge. Any radiation which is capable of causing this effect is known as ionising radiation (see Glossary, Appendix 2). These are not to be confused with non-ionising radiations such as light and microwaves.

Ionising radiations emitted from radioactive atoms or produced by devices such as x-ray machines include:

- alpha ($\alpha$) particles
- beta ($\beta$) particles
- gamma ($\gamma$) particles
- xrays

Due to the identity of waves and particles on a microscopic level some types of radiation (alpha and beta) are particles, while others (gamma and x-rays) would be commonly classified as waves or rays. These are the only directed ionising radiations with which we will be concerned.

Alpha particles are identical with helium nuclei, having two protons and two neutrons. Alpha particles thus carry a positive charge and 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 heavy ionisation to take place. Alpha particles thus have very little power of penetration and are stopped completely by a 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 used at the University except under exceptional circumstances.

Beta particles are high speed electrons (ie negatively charged) emitted from the nuclei of radioactive atoms. Being light (almost no mass), and emitted with a speed close to 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.

In practice, the most commonly used shielding for beta particles is aluminium or perspex. Lead is not an effective shielding as absorption of beta particles gives rise to secondary radiation by the bremsstrahlung process in the form of x-rays. Aluminium and perspex do not give rise to secondary radiation of any significance.

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.

Gamma rays 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 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.

## Radiation Units

### Energy
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, is, kilo or million electron volts.

### Radiation 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. This unit is not often used and the old unit was the Roentgen (R).

### Radiation Absorbed Dose (Gray)
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 doses usually encountered are likely to lie in the milligray (mGry) or microgray (mGy) region. For example, a chest x-ray gives about 200 microGray to the Chest wall, while a radiotherapy treatment may involve 60 Gy (300,000 times as much as the chest x-ray).

Note that the tissue or material involved must also be specified along with the absorbed dose. The old unit of absorbed dose is the rad, which is equal to 0.01 Gray.

### Equivalent Dose (Sievert)
This unit is a measure of the biological effect produced, for equal energy absorption, by different types of radiation as well as other effects. The relation between dose equivalent and absorbed dose is given by:

**Sieverts = Grays x WR x N**

Where WR is the radiation weighting factor depending on the type of radiation, and N is the product of all other modifying factors. Table 2.1 lists the radiation weighting factor according to ICRP.

**Table 2.1 Radiation Weighting Factors** (1)

| Type & Energy Range | Radiation Weighting Factor |
|---|---|
| Photons, all energies | 1 |
| Electrons and muons, all energies (2) | 1 |
| Neutrons, energy | 5 |
| Less than 10 ke V | 10 |
| 10 ke V to 100 ke V | 20 |
| Greater than 100 ke V to 2 Me V | 10 |
| Greater than 2 Me V to 20 Me V | 5 |
| Greater than 20 Me V | 5 |
| Protons other than recoil protons, energy greater than 2Me V | 5 |
| Alpha particles, fission fragments, heavy nuclei | |

(1) All values relate to the radiation incident on the body, or for internal sources, emitted from the source.
(2) Excluding Auger electrons emitted from the nuclei bound to DNA.

For most radiation encountered in the University environment WR is nearly equal to 1, also N is currently taken to be equal to 1, so that dose equivalent often is numerically equal to absorbed dose. The Sievert is again therefore a rather large unit and most dose equivalents will be in the millisievert (mSv) and microsievert (mSv) range. The old unit of dose equivalent is the Rem which equals 0.01 Sievert.

**Activity (Becquerel)**
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. Each disintegration is associated with the emission of ionising radiation of some sort. The Becquerel is a very small unit, and the usual activities encountered in the University are in the Kilobecquerel (kBq), Megabecquerel (MBq) or Gigabecquerel (Gbq) range. The old unit of radioactivity is the Curie which equals 3.7 x 1010 Bq.

**Half Life (Radioactive Decay)**
Radioactive decay is proportional to the total number of atoms in a system. with the result being that radioactive decay is exponential. It may be described by the formula:

$$A_t = A_o\, e^{-\gamma t}$$

Where: $A_o$ = original activity
$A_t$ = activity at time
$\gamma$ = radioactive decay constant

The half life ( T1/2 )of a radioactive species is the time taken for half of the material to decay is the disintegration rate to reduce to half its original value. The greater the stability of a species the longer it takes to decay (has a longer half life), the less stable the species the shorter length of time it takes to decay, ie a shorter half life.

The half life of a particular radioactive isotope is constant, the radioactive decay occurring at a characteristic rate for each element. Therefore measurement of the half life can assist in identifying the composition of unknown radioactive samples.

Radiolytic Self Decomposition varies according to the storage, sensitivity of the compound, solvent (type and purity) and affects the usefulness of the compound, eg 3H thymidine.

**Biological Half Life**
This refers to the time taken for half an administered or ingested amount to be excreted by the body, this value having nothing to do with radiation. Please note that after two half lifes there is still one-quarter of the original activity present. Waiting for 10 half lifes reduces the activity to 0.1% of the original activity.

## 2.3 Sources of Ionising Radiation

There are a number of possible situations:

- exposure may be experienced in the workplace (occupational exposure), by members of the public or due to medical treatment.
- the nature of the exposure may be intentional or accidental.

It is interesting to note that 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 2mSv.

**Table 2.2 - Average Annual Radiation dose to the Population (UK Data)**

| Source | Percent |
|---|---|
| Radon | 23 |
| Medical | 21 |
| Internal | 16 |
| Gamma Ray | 16 |
| Cosmic Ray | 13 |
| Other (1) | 1 |

(1) Includes - discharges, occupational, fallout and miscellaneous.

## 2.4 Ionising Radiation - The Risks Involved

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 (that is, no threshold) which would probably overestimate rather than underestimate the risk. The risks in the table 2.3 represent the overall risk to all age groups over a period of 20 to 25 years. In the case of genetic risk (hereditary effects) the risk estimated is for the next and succeeding generations (ref. ICRP 26).

**Radiation at the Cellular Level**

The effects of radiation depend greatly on whether the exposure is delivered as a single fractionated or continuous dose. Generally, the fact that several small doses of radiation cause less damage than a single dose of the same magnitude indicates that mammalian cells have a capacity to repair damage caused by radiation. This damage repaired within a few hours of exposure, means that something like 90% or more of lesions to DNA, chromosomes, etc, are efficiently repaired when radiation doses are smaller and cells have time to repair themselves.

Differentiating cells and cells undergoing division are much more sensitive to radiation e.g. the radiation hazard is 100 times greater for the foetus during the 3rd-7th week than for the pregnant mother.

Organs and tissues in which the cells are replaced slowly also exhibit high radiation sensitivity. The human tissues which exhibit higher than normal sensitivity to radiation damage are:

- reproductive organs
- skin
- organs of the abdominal cavity
- eyes
- blood forming organs in the spleen and bone marrow
- tissues of the nervous system

In general, the more differentiated the cells of an organ are the greater the sensitivity to radiation.

Alpha-radiation is more hazardous to the cell as the dense ionisation column of alpha-radiation leads to disruption of the DNA molecule. On the other hand, a gamma-ray photon may pass even a whole chromosome without causing a chromosome disruption or structural charge. However, any radiation whether a, b or g causes radiolysis of the water in the cell and the products may react with the DNA or RNA to such an extent that the cell dies.

**Table 2.3 Radiation Risks**

| Tissue or Organ | Risk per mXv Received | Nature of Risk |
|---|---|---|
| Bone Marrow | 2 in 1,0001000 | Leukaemia |
| Bone | 5 in 10,000,000 | Various |
| Lung | 2 in 1,000,000 | Cancers |
| Breast | 2.5 in 1,000,000 | Hereditary |
| Thyroid | 5 in 10,000,000 | Defects |
| Other tissues | 5 in 1,000,000 | |
| Total Body | 1 in 100,000 | |
| Gonads | 4 in 1,000,000 | |

The actual risk per annum due to a given radiation dose is difficult to compute since it will vary with the latent period after irradiation and any subsequent radiation received in the interim. However, this risk per annum from an individual dose will certainly be a lot smaller than the overall risk quoted above. In order to put the above risk in perspective the risks from various other causes of death are compared below with the risk per year of death for:

- a hospital radiation worker receiving around 2mSv per annum (a typical figure) over a working period of many years.
- a patient receiving 20mSv bone marrow dose as a result of some diagnostic procedure involving radiation.

The risk of death each year from lung cancer is 1 in 4000; from murder is 1 in 100,000; from a car accident is 1 in 5000; from leukaemia as a result of radiation worker receiving 3mSv per year for many years is 1 in 130,000; and from leukaemia as a result of receiving significantly less than a single exposure of 20mSv to bone marrow is 1 in 25,000.
It can be seen from the above table that, under normal circumstances, the risk is relatively small compared with the risk of death from other causes. However, it cannot be described as being negligible and current policy is to keep the radiation exposure of workers as low as is practicably feasible. In the case of patients irradiated during some diagnostic or therapeutic procedure involving ionising radiation there are definite risk versus benefit considerations. Often the benefit of the diagnostic information far outweighs the radiation hazard, and for older patients the associated hereditary portion of the risk will obviously be negligible.

Also, the risk associated with a patient's illness may be such that any additional hazard due to radiation will be insignificant. In spite of this, a policy should be maintained that no examination involving ionising radiation should be performed if little or no additional information is likely to be obtained from this examination. Multiple tests involving ionising radiation are also to be discouraged, bearing in mind the cumulative nature of the risk.

It is generally accepted that the tissues and organs of children are more radiosensitive to those of adults. Also, the foetus is particularly sensitive to radiation, especially during the 3-7 week period. Risks of the order of 4 in 10,000 (per mSv) have been quoted for irradiation of the foetus in utero. For the above reasons the irradiation of pregnant women or children needs special consideration. If an examination involving radiation is considered absolutely necessary, then steps must be taken to keep the radiation dose at a minimum (see Section 13).

## 2.5 Organisation of Radiation Safety

The overall responsibility for Radiation Safety and Protection at The University of Newcastle rests with the Vice-Chancellor. An employer is required to protect employees, (and in this case, students), members of the public and the environment from unnecessary exposure to radiation arising from their operations which may use radiation apparatus and/or radioactive substances. The Vice Chancellor has chosen to appoint a University Radiation Safety Officer/Radiation Safety Advisor for the University (URSO) to assist the institution to fulfil its

obligations under the Act. A Radiation Safety Committee (RSC) has also been appointed to act as an administrative and consultative body that reviews the radiation safety of all uses of ionising and non-ionising radiation and radioactive substances within the institution and to recommend implementation of radiation safety policies within the organization. The University Radiation Safety Officer/Radiation Safety Advisor is the Chair of the Radiation Safety Committee which can report directly to the Vice Chancellor but normally works through the University's Occupational Health and Safety Committee. The RSC through the OH&SC is thus able to give direction, stop procedures or impose conditions when in its considered opinion the safety of staff, students or general public is being significantly compromised. The RSC will normally act through the Manager, Health and Safety Team however the URSO may also act without direction of the Committee if and when safety of staff, students or general public is being significantly compromised.

The Radiation Safety Committee covers matters relating to ionising and non-ionising radiation safety and its activities include receiving regular reports from the University Radiation Safety Officer/Radiation Safety Advisor, consideration of research proposals involving radiation or radioactive material, investigations of incidents involving radiation, approval of procedures for uses of radiation and inspection of areas where these procedures are carried out.

Within each relevant school or building where members of the University staff or students carry out activities, a local Radiation Safety Officer (usually the representative to the Radiation Safety Committee) is appointed.

## 2.6 Responsibilities

**2.6.1** The Occupational Health and Safety Act of NSW (2000) and the Radiation Control Act of NSW (1990) established a legally enforceable "duty of care" on all employers and employees to maintain a safe working environment. In other words, a Supervisor/Manager can be found guilty under the Act for failing to maintain a safe environment by acts of either commission or omission and be held liable.

Similarly, an employee can be found guilty of contributing to an unsafe working environment in his/her immediate vicinity again by acts of commission or omission, and held liable.

**2.6.2 University Radiation Safety Officer/Radiation Safety Advisor**

The NSW Radiation Control Act 1990 allows for the appointment of a Radiation Safety Officer/Radiation Safety Advisor in institutions where ionising radiation is in routine use. The University Radiation Safety Officer/Radiation Safety Advisor has a number of duties laid down in the regulations to the Act which, when summarised, require the Advisor to supervise the practices of radiation safety in the institution, ensure the maintenance of records and to report to that institution's Radiation Safety Committee, in this case the Radiation Technical Sub-Committee of the Occupational Health and Safety Committee.

The University Radiation Safety Officer/Radiation Safety Advisor is responsible to the Vice-Chancellor through the Associate Director, Health and Safety Team.

**2.6.3 School/Discipline/Building Radiation Safety Officers**

The School/Discipline/Building Radiation Safety Officers have the overall responsibility for ensuring the safe use and disposal of radioactive material and the use of irradiating equipment within their areas and for maintaining the records required in the Act and for administering the personnel monitoring program. They are responsible to the University Radiation Safety Officer/Radiation Safety Advisor and, ultimately, the Occupational Health and Safety Committee.

They should ensure that the appropriate staff wear personal radiation monitors, that procedures and local rules governing the uses of ionising radiation are drawn up and adhered to, also that waste removal practices are decided upon and followed etc. They are required to carry out regular inspections to ensure that rules and regulations are being complied with and have the authority to order that all activities cease until safe working procedures are in place and are being followed.

The School/Discipline/Building Radiation Safety Officer and/or the University Radiation Safety Officer/Radiation Safety Advisor may be contacted for advice on the above, but it should be stressed that the Head of School and Chief Investigators of research projects utilising radiation have the responsibility for ensuring that correct licenses are in place, staff are trained and students are supervised.

**Individual** - The individual worker has obvious responsibilities to both himself and his co-workers in ensuring that safe practices are devised and adhered to. There is nothing particularly special about ionising radiation in this respect. Any hazardous material or environment requires a certain amount of common sense and caution and ionising radiation is no different. Each worker should be responsible for the irradiating apparatus or radioactive materials used in a procedure until such stage as a finished product is obtained and/or waste is removed from the laboratory. Those staff dealing with patients must also ensure that not only their own, but also the patient's exposure to radiation is minimal, consistent with the procedure involved. Workers who have been assigned a personal monitor are responsible to wear it all the time when at work.

## 2.7 Continuing Education

All staff commencing work with or in areas where ionising radiation is used has to be introduced to the particular problems arising from the radiation by the Chief Investigator for the laboratory in which the assistance of the local Radiation Safety Officer may be sought. This induction should be as early as possible after commencement of the position.

The Regulation (2003) of the Radiation Control Act of NSW (1990) indicates that a certain level of training will be required of applicants for a licence. The Laboratory and Research Safety Officer in Human Resource Services, Health and Safety Team, will provide information on training courses from time to time and if necessary provide the requisite training. All costs of such training will be borne by the applicants or their supervisors. Provision of training for licence qualification is not the responsibility of the University.

From time to time there will be training and updating seminars on radiation protection provided by the Health and Safety Team. Information on these seminars will be circulated to all licence holders.

## 2.8 NSW Regulations

The NSW Radiation Control Act 1990 in the Regulation (2003) sets down regulations governing the use of "irradiating apparatus" and radioactive substances. This Act is administered by the Environmental Protection Authority (EPA), Radiation Information Services Centre (Radiation Control Section), phone: 02 9995 5959, fax: 02 9995 6603, email: radiation@epa.nsw.gov.au) with the overall responsibility resting with the NSW Radiological Advisory Council. Officers from the EPA may inspect institutions from time to time to ensure compliance with the regulations. They are also available for consultation on various forms of radiation protection.

The Regulations are based on recommendations made by the International Commission on Radiological Protection (ICRP), World Health Organisation and the National Health and Medical Research Council. It is impossible here to cover all aspects of the Act; some of the important points to note, however, are as follows:

### 2.8.1 Licences

The University Radiation Advisor is the responsible officer for radiation licensing matters. Any person carrying out work involving irradiating apparatus or radioactive substances must be licensed to carry out such work unless they have been issued with a formal exemption and be working under the direction and supervision of a person holding such a licence. The EPA issues such licences (application or renewal available from this link) to suitably qualified persons and has the power to withdraw or withhold licences where deemed necessary.

### 2.8.2 Monitoring

All radiation workers should have their radiation exposure monitored by some means. Usually a badge is used for this purpose. It is also mandatory that a record of exposure of each radiation worker be kept by the licensee or employer. At the University of Newcastle records are kept by the relevant School/Discipline/Building Radiation Safety Officer.

### 2.8.3 Control of Radiation Exposure

The radiation exposure of any radiation worker should not exceed limits set down by the Act. Limits are also set down for members of the public (see Appendix 4). The equivalent dose limits are constantly under review by the ICRP, and may be changed.

### 2.8.4 Labelling of Radioactive Substances

No person shall have any source of radiation in his/her possession unless it is clearly marked with the words "CAUTION-RADIOACTIVE". This source should also be stored in a properly shielded container on which is legibly written details with regard to the nature of the radioactive source within, including the radionuclide, activity and date.

### 2.8.5 Restricted Areas

Areas where there may be a hazard from ionising radiation should be clearly marked with the approved radiation hazard sign.

Further details on the above, and other subjects such as packaging, contamination, labelling and transportation of radioactive substances, etc, may be obtained from the University Radiation Safety Officer/Radiation Safety Advisor.

## 2.9 Licences

**2.9.1** Section 6 of the Radiation Control Act NSW (1990) states that:

> *"A person must not use, sell or give away anything to which this section applies (radioactive substance, ionising radiation apparatus or prescribed nonionising radiation apparatus) unless the person is the holder of a licence or temporary licence".*

This means that anyone who operates x-ray analysis equipment on therapeutic x-ray equipment or who handles the prescribed amount of radioactive substance must have a licence. The prescribed amounts are given by the formula where A1, A2, A3, and A4 are the total activity in kilo becquerels of Group 1, 2, 3 and 4 Radioisotope (see Appendix 1) This includes research assistants and laboratory technicians.

There will be a training component that applicants for licences will have to satisfy. The University organises one training course each year depending on minimum numbers.

Licence forms are available from this link, the Radiation Information Services Centre (Radiation Control) of the EPA of NSW, or your School/Discipline/Building Radiation Safety Officer may maintain a supply. All expenses incurred in obtaining a license are the responsibility of the applicant. All licence applications and renewals are sent to the

University Radiation Safety Officer/Radiation Safety Advisor for co-signing. The University Radiation Safety Officer/Radiation Safety Advisor maintains a register of all licence holders.

### 2.9.2 Exemptions

There are exemptions to the requirement for licences and these apply mainly to students and are as follows:

1. a person who is a student in medical radiation technology and is a trainee technologist in nuclear medicine, diagnostic radiology and radiation oncology;
2. an undergraduate student in a university or other educational institution who is undertaking course work or research;
3. a postgraduate student in a university or other educational institution who is undertaking research or higher studies.

These exemptions must be confirmed by the Supervisor/Licence Holder and must be in writing specifying the radioactive substance(s) or irradiating apparatus and set out any specific conditions and must identify the person and their supervisor. (See Appendix 6.)

The supervisor then has specific responsibilities:

1. A person referred to in 1 and 2 above must have immediate supervision while the person is using radioactive substances or radiation apparatus during clinical experience and general supervision at all other times by a qualified person.
2. A person referred to in 3 above (ie a postgraduate student) must have general supervision at all times by a qualified person. Clearly, the simplest way to cover the situation (although perhaps not the most economical) would be to train up the post-grads and purchase full licences for them.

### 2.9.3 Licences for Teaching and/or Demonstration Purposes

Members of staff who are involved in the teaching of both postgraduate students with exemptions or undergraduate students in the safe use and disposal of unsealed radioisotopes (where each student uses substantial quantities), the use of x-ray analysis equipment, and therapeutic x-ray equipment are required to be specially licensed. Again these licences (category Iq and Rq) are available from the Radiation Information Services Centre of the EPA.

### 2.9.4 Supervision

"**general supervision**" means supervision by a qualified supervisor who oversees the person being supervised and ensures that the person follows safe radiation work practices in relation to the use of radioactive substances or radiation apparatus;

"**immediate supervision**" means supervision by a qualified supervisor who is present at all times during, and is observing and directing, the use by the person being supervised of radioactive substances or radiation apparatus;

"**qualified person**", in relation to supervision for a particular radioactive substance or item or radiation apparatus, means a person who is the holder of a licence which allows the person to provide supervision with respect to that substance or item.

### 2.9.5 Duty to Inform Occupationally Exposed Persons

Any person commonly working in an area where prescribed amounts of radioisotopes or irradiating apparatus are being handled must be made aware of all hazards and risks associated with the procedures and of all safety arrangements. This applies whether the staff or student are actually carrying out the procedures.

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## Section 3: Personnel Monitoring Service

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### 3.0 General

Film badges which have been used for personal dosimetry are now completely replaced by TLD badges. They are distributed by the Personal Radiation Monitoring Service of the Australian Radiation Protection and Nuclear Safety Authority (ARPANSA):

619 Lower Plenty Road, YALLAMBIE, VIC 3085
Phone: 1800 678 112
Fax: 03 9432 1835
Email: prms@health.gov.au
Website: http://www.arpansa.gov.au/prms.htm

There is a charge for this service and payment is not the responsibility of the University.
As part of the service ARL is keeping a register of the personal doses received by all persons registered with them. This is a personal (and confidential) register, ie it is not linked to the employment of a person with a certain employer.

### 3.1 Principles of Thermolumnescence Dosimetry

The thermoluminescent dosimeter (TLD) is a device which allows much faster evaluation than the film badge, with a lower threshold.

When a TLD material is exposed to ionising radiation at room temperature, part of the energy absorbed is used in changing the energy state of electronics in the material. If the TLD is heated, these energy states revert to their normal level accompanied by the emission of light. Portion of this light emission may be measured and is directly proportional to the amount of radiation energy received by the dosimeter.

TL dosimeters may be used in the form of a body badge similar to a film badge, a finger badge to measure extremity dose, or tiny rods or chips which may be sued to check internal doses using dummies.

### 3.2 Organisation of the Personal Monitoring

The School/Discipline/Building Radiation Safety Officer is responsible for the personal monitoring of staff in the different departments. This responsibility includes:

- decision which members of staff shall wear personal monitors
- issuing of TLD badges to staff in regular intervals
- informing staff about proper use of the badges
- keeping a record of the results
- updating members of staff on the recorded personal dose if requested
- informing the Radiation Safety Committee if doses are recorded which exceed the limit values given in Section 3.4 - Significance of the TLD Results.

As a rule of thumb, only persons required to work in a medium level laboratory need to be constantly monitored - see Section 5.

Each member of staff is responsible for wearing the TLD badge all the time when at work. Since TLD badges are a record of the occupational exposure they should not be taken home.

Any member of staff should contact the Departmental/building or the U University Radiation Safety Officer/Radiation Safety Advisor if they feel they should be monitored.

In most areas the TLD badges are changed every 12 weeks. However, in exceptional circumstances (such as a radiation accident) the University Radiation Safety Officer/Radiation Safety Advisor can organise for an immediate readout. Please contact the RSO if this is required. If a member of staff is engaged in a procedure involving higher than usual radiation levels, or had a need to double check their radiation exposure, eg if pregnant, then further advice can be obtained from the University Radiation Safety Officer/Radiation Safety Advisor.

TLD badges are the main personal monitoring equipment. However, other means of personal monitoring, such as finger rings, may be more appropriate for certain tasks. This can be arranged by the University Radiation Safety Officer/Radiation Safety Advisor on request.

Laboratories or sections that handle a number of short-term visitors from other institutions requiring a report on radiation exposure must make arrangements ahead of time to ensure that the visitor has a badge to wear or purchase one immediately registering personal dosimeter to be worn for the length of stay.

### 3.3 HANDLING OF THE TLD BADGE

The radiation TLD badge is used to measure the amount and type of radiation received by the wearer over a period of time (typically 3 months). It plays an important part in radiation safety, providing a check of the adequacy of protection measures, and in the case of a radiation accident an assessment of the dosage received by the wearer. Failure to observe these rules can result in misleading assessment of radiation exposures.

**Precautions to be taken**

1. Always use the TLD sachet inside the holder supplied. The holder incorporates filters which allow an assessment of the radiation quality.
2. Wear the holder correctly. The ARL symbol should face away from the body.
3. Do not damage the badge. Pin holes, water, pressure, chemicals and heat can damage the TLD badge and prevent evaluation of the dose.
4. Do not store TLD badges near radiation sources when not being worn.
5. Return the TLD badges promptly. Badges must be returned to ARL upon receipt of a new batch. Extended delay increases the chances of accidental exposure of the badge. Also, in case of a dose recorded by the badge it is important to evaluate it as soon as possible so action can be taken to prevent exposure in the future. If it is suspected that a person has received a significant radiation dose, please return the TLD badge for assessment immediately!
6. Always wear the TLD badge under a lead apron, if used. Since the badge is used to measure radiation exposure to the body, it should not be worn outside of protective clothing. Similarly, care should be taken not to shield the badge by pens, buckles etc.

### 3.4 SIGNIFICANCE OF THE TLD RESULTS

The permitted levels of radiation allowed for occupationally exposed workers and members of the general public have been laid down by the ICRP (report 60, 1991) as amended in the "National standard for limiting exposure to ionizing radiation" (National Occupational Health and Safety Commission publication 1013 (1995)). They are incorporated in the NSW Radiation Control Act Regulation (2003).

The permitted levels are as follows:

- Occupationally exposed persons

| | |
|---|---|
| Effective dose limit | 20mSv per annum<br>Averaged over a period of 5 consecutive calendar years |
| Effective dose limit in a single year | 50mSv |
| ***Equivalent dose limit:***<br>In the lens of the eye<br>In the skin<br>In the hands and feet | 150mSv per year<br>500mSv per year<br>500mSv per year |

- Others, including members of the general public - 1mSv per annum

**(When an employee declares that she is pregnant, the embryo or foetus should be afforded the same level of protection as required for members of the public.)**

In general, TLD badges provide a measure of the whole body dose received. For practical purposes the allowable limit can be taken to be 0.5 mSv per week, for radiation workers. However, it is recommended that any radiation dose received by a person should be kept to the minimum value practical. The School/building or University Radiation Safety Officer/Radiation Safety Advisor is available to assist in the minimisation of radiation exposure to personnel.

### 3.5 MAINTENANCE OF RECORDS

1. It is the statutory duty of the School/Building X-Ray Centre Radiation Officer to ensure that appropriate personal records are maintained of each individual's radiation exposure for whom they are organising a monitoring service.
2. Such a record must contain:
    - The full name, sex and date of birth of the occupationally exposed person.
    - The current home address of the occupationally exposed person, or if no longer employed, the last known address.
    - The date of commencement of employment or commencement of activities possibly leading to occupational exposure and the date of cessation of employment or cessation of those activities.
    - The kind of work performed by the occupationally exposed person .
    - Details of the types of ionising radiation to which the person has been occupationally exposed including the type of unsealed isotopes involved.
    - Details of any radiation accidents in which the person was involved in which may have affected their exposure in the workplace.
    - Details of the personal monitoring devices worn during the time when the person may have been occupationally exposed.
    - Results of monitoring the levels of radiation exposure
3. When an employee leaves employment or a student who has been monitored completes the period of study during which they may have been exposed the employee or student must be given a copy of their records relating to the period of possible occupational exposure.

    If the employer/Radiation Advisor is aware that the person is taking up further employment on study involving possible exposure then a copy of the exposure record must be given (if the employee/student consents) to the future employer or student supervisor.

4. The record of exposure given to the employee or student must contain the statement:

   "**THESE RECORDS SHOULD BE KEPT SAFELY AND BE GIVEN TO ANY FUTURE EMPLOYER OR SUPERVISOR OF STUDY/WORK PERFORMED IN AN AREA WITH RISK OR EXPOSURE TO RADIATION. THEY CONTAIN INFORMATION OF PERMANENT APPLICATION.**"

   The Radiation Advisor must ensure that records are maintained in a form and place where they are available for inspection by the person to whom they relate at reasonable times during normal working hours.

# RADIATION SAFETY MANUAL

## Section 4: Purchasing Procedures

### 4.1 Radioactive Materials

Suppliers of radioactive substances and irradiating equipment should only sell to licensed persons. However it is the institution that holds the licence to hold and sell (and purchase isotopes).

A complete central record of all purchases must be maintained and monitored. The particulars of the radioactive substances should also be recorded on an inventory held at the place of storage.

All orders of:

- radioisotopes / unsealed sources,
- equipment emitting ionising radiation / sealed sources, e.g. X-rays,
- equipment emitting non-ionising radiation, e.g. Lasers, RF-heating, laboratory microwaves, sonic, MRI,

must be approved by the University prior to being placed.

A form is being developed for radiation orders but in the interim the details of any proposed radiation order (project title, safety review ref number, responsible person, who is using it, licence details, what is being ordered- how much, what activity etc.) should be forwarded to radiation@newcastle.edu.au where it will be assessed and forwarded to the DVC(R) for approval.

### 4.2 Irradiating Apparatus

Irradiating apparatus is ordered using normal procedures, however, each purchase or intended purchase should be notified prior to order, the Radiation Safety Committee via the University Radiation Safety Officer/Radiation Safety Advisor.

Designs of installations where radiation will be used, or modifications to existing installations, should be submitted to the University Radiation Safety Officer/Radiation Safety Advisor for checking of shielding and reporting to the Chemical and Radiation Technical Sub-Committee before the design is finalised.

It must be emphasised that all irradiating apparatus installations are subject to review by the EPA who may and will prevent their operation if they are not satisfied with radiation safety measures. For advice contact the University Radiation Safety Officer/Radiation Safety Advisor.

# RADIATION SAFETY MANUAL

**Section 5: Use of Radioisotopes in the Laboratory**

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## 5.0 General

All users of radioisotopes must have areas designed specifically for the handling, storage and disposal of radioisotopes. A number of basic rules apply to the use of radioisotopes and to storage and disposal of radioactive waste. Please refer also to Australian Standard 2243.4 (1998).
All laboratories must comply with the general University Laboratory Safety Policy and follow the Guidelines for Safe Laboratory Practice.

**There will be annual inspections of all Laboratory areas.**

## 5.1 Radioisotope Laboratories

The Australian Standard classifies laboratories into Low, Medium and High level laboratories. Classification of radiotoxicities in Schedule 1 of the Regulations (2003) (see Appendix I) can be incorporated in a grading system that relates the standards of finish and facilities in a laboratory to the amounts of unsealed radioactive materials that can be used safely in it. Table 5.1 shows laboratory gradings for normal, wet chemical operations. Because of the potential for radioactive contamination is largely determined by the nature of the work (eg storage presents a reduced risk, whereas dusty operations increase the inhalation hazard), the factors shown in Table 5.2 can be applied to modify the grading according to the operations performed in the laboratory.
Labelled organic material of special biological importance may be metabolised differently to the elemental form, and hence may present a greater hazard than normal. For example, 3H-labelled or 14C-labelled thymidine is not metabolised but is retained intact by the body. In such cases, an additional grading factor of 0.1 should be applied.

**TABLE 5.1 Grading of Radioisotope Laboratories**

**Radiotoxicity Class I**
Low level activity laboratory - <0.2 MBq
Medium level activity laboratory - 0.2 MBq to 20 MBq
High level activity laboratory - >20 MBq

**Radiotoxicity Class II**
Low level activity laboratory - <20MBq
Medium level activity laboratory - 20 MBq to 2 GBq
High level activity laboratory - >2 GBq

**Radiotoxicity Class III**
Low level activity laboratory - <2 GBq
Medium level activity laboratory - 2 GBq to 0.2TBq
High level activity laboratory - >0.2 TBq to 20 TBq

**Radiotoxicity Class IV**
Low level activity laboratory - <0.2 TBq
Medium level activity laboratory - 0.2 TBq to 20 TBq
High level activity laboratory - >20 TBq

**TABLE 5.2 Grading Factors**

| Procedure Factor | Factor |
|---|---|
| Simple storage | x 100 |
| Very simple wet operations (eg preparation of aliquots of stock solutions) | x 10 |
| Normal chemical operations (eg analysis of simple chemical preparation) | x 1 |
| Complex wet operations (eg multiple operations, or operations with complex glass apparatus) | x 0.1 |
| Simple dry operations (eg manipulations of powders) and work with volatile radioactive compounds | x 0.01 |
| Complex dry operations (eg where powders are likely to become airborne) and work with radioactive gases | x 0.001 |

We have no high level laboratories in the University - most would be low level with a few at medium level. The "radiation rooms" where stock solutions are prepared and iodinations performed would be classified as medium level.

## 5.2 Low Level Laboratories

Generally, this is where amounts of radioisotope diluted below the prescribed amount (Schedule 1 Appendix I). However it is paramount that there be signs indicating what part of the laboratory is used for these functions, and only one designated and labelled sink be used for disposal.

## 5.3 Medium Level Laboratories

The ideal medium level radioscope laboratory should:

1. Have restricted access and minimum traffic
2. Display radiation warning signs
3. Be equipped with benches with surfaces which lend themselves to decontaminisation, eg stainless steel
4. Have an easily decontaminated floor, preferably continuous vinyl (with welded seams) extending about 10cm up the walls.
5. Shall be equipped with a radiation contamination monitor appropriate for the isotopes and energies used.
6. Have storage areas for bulk radioisotopes and radioactive waste, shielded if necessary. Normally, unsealed isotopes will be stored in a refrigerator/freezer with a lock, appropriate signage and a list attached of the contents.
7. Have a designated sink where low activity radioactive material may be disposed of exclusively.
8. Have a log of radioactive materials used and disposed of. If the area is to be used as a "hot lab" for bulk quantities of radioactive material or procedures such as protein iodination, the following is also required:
9. A fume cupboard with appropriate shielding for handling high specific activity materials
10. The whole area must be able to be securely locked with entry to only authorised persons.
11. Basic decontamination equipment must be readily available.
12. A log is to be kept of all bulk supplies of radioactive materials received in the "hot lab" along with information as to eventual disposition.
13. The licensee has overall responsibility for the maintenance of documentation and logs. This will be checked periodically by the school/building Radiation Safety Officer.

## 5.4 Storage of Radioactive Materials

5.4.1 As mentioned above, all stock solutions of radioisotopes must be stored in a locked refrigerator/freezer in the Radiation Room or in a designated and well labelled refrigerator in the laboratory adjacent to the Radiation Work Area. Any high activity working solutions must also be stored there.5.4.2 All items thus stored must be marked with the users name and a description of the contents, ie name of isotopes, amount of activity, date.

5.4.3 This information must also be entered in a register5.4.4 Any items not properly stored and marked should be disposed of.5.4.5 Any material that has expired, or is no longer in use must be disposed of appropriately by the user.

## 5.5 Safe Use of Radioisotopes

5.5.1 All radioactive material must be considered potentially highly dangerous, and be handled accordingly. As a minimum, the precautions used in sterile techniques for handling pathogenic material should apply at all times.

**Please Note: Pipetting by mouth is not permitted.**

Any person using radioactive material for the first time must consult the Radiation Officer for the area, and satisfy the following criteria:

- that they understand the procedures being used
- that they understand, and have in place, procedures for monitoring the laboratory and personnel, procedures for separation and disposal of waste and in the event of a spill or other emergency, know what steps to take.

5.5.2 For work in low level laboratories, a normal laboratory coat or overall is sufficient. For work in medium level laboratories, the laboratory coat shall have elasticized sleeve cuffs and a crossover front with high neck fastened with velcro strips. Pockets are not recommended.5.5.3 Care must be taken to avoid cuts or puncture wounds. Cracked or chipped vessels are not to be used. Any small existing wound should be covered with waterproof dressing during procedures using radioactive materials.5.5.4 If there is a risk of splashing during an experiment, eye protection must be worn. Disposable gloves should be worn for all procedures involving radioactive concentrations greater than 1kBq/ml, or total activity greater than 100 kBq. Gloves should be checked with a radiation monitor before disposal. If they exhibit no detectable contamination, then there is no need to treat the gloves as radioactive waste and they can be placed in the normal laboratory bin. If, however, there is contamination 2X background or more, then they must be treated as solid radioactive waste and disposed of as indicated in section 4.8 below.

**Please Note:** It is important not to handle non-contaminated objects with contaminated gloves, particularly if they are not part of the procedure, i.e. door handles, taps, any multiple user item. A radioactive worker must be conscious of this when planning the procedure and if necessary be prepared to use a number of pairs of gloves.5.5.5 All work with unsealed liquid sources shall be carried out in a double container or over large trays (eg stainless steel or plastics) lined with absorbent paper to restrict the spread of any spilt liquid.

5.5.6 Hands should be washed and hands and clothing checked with the radiation monitoring equipment at the completion of procedures.

5.5.7 A radiation monitor, with a probe appropriate for optimal detection of the energy or particles being emitted by the isotope in use, should be nearby and switched on to "audio" during all manipulations. If there is doubt concerning the appropriate monitor, then the Radiation Officer should be consulted.

5.5.8 All operations or manipulations with the isotopes as delivered should be carried out in "Radiation Room" which should be clearly designated with appropriate warning signs. If it is absolutely essential that some procedures are carried out in ordinary laboratories then initial

dilutions of isotope must be carried out in the Radiation Room and the diluted isotope carried back to the laboratory for subsequent work.

a) Radioisotopes, clearly labelled with the name of the owner, should be stored in the freezer/refrigerator in the Radiation room. Any high activity diluted solutions should also be stored here.All reagents, tools and, where possible, apparatus used in the 'active' area shall be clearly labelled (eg with paint), and normally remain in the 'active' areas. Where any item needs to be taken out of the 'active' area, it shall be monitored, decontaminated if necessary and labelled. The label shall identify the laboratory, date and show a signature and the name of the person certifying that the item is free from contamination.All radioactive preparations shall be clearly marked with the radiation symbol and details of the chemical compound, radionuclide, activity, date and name of responsible user.It is the user's responsibility to ensure that all material is disposed of once it has expired or it is no longer required. When working with a particular element or compound, the total toxicity must be taken into account in its use. The total toxicity may be more than is indicated by the radioactive isotope itself. For example, the compound may be a heavy metal, or carcinogen or a metabolic poison. These features may dictate the specific manner in which a substance is to be handled, in addition to the normal radiation safety requirements. It is the responsibility of the person working with the materials, as well as the Chief Investigator/Team Leader, to ensure that they are aware of all safety ramifications of the substance(s) being used.

**5.5.9 Designation of Work Area** It is essential that any area in the laboratory where work with radioisotopes is being performed, be clearly marked and every precaution taken to contain any accidents or spills. At the very least, this area should be marked with radioactive warning tape and lined with a disposable bench covering such as Bench-Kote. In addition, staff who regularly work with radioisotopes should have access to, or have constructed, a plastic or stainless steel tray to place on the bench when working with radioisotopes. The tray should be of size to conveniently contain all required equipment and a "lip" sufficient to prevent the spread of any potential spill.

**5.5.10 Shielding** Ideally any work requiring shielding should not be conducted in an open laboratory. However, many beta emitters (14C, 32P, 3H) and weak Gamma emitters (59Fe 5I (bound) 51Cr) can be safely manipulated behind a work station constructed from 1.0-1.2cm thick perspex. These can be purchased from a number of suppliers, (eg Amersham, ICN). In addition, for work with concentrated solutions and strong gamma emitters, which should only be performed in a Radiation Room, lead shielding or lead brick walls may be necessary to protect the worker from unnecessary exposure. Details of such shielding should be available from your Radiation Officer.

5.5.11 Radioactive iodine and any other volatile or sublimating isotope or isotope dissolved in a volatile dilutent must be processed in the Fume Hood in the Radiation Room.

5.5.12 After completion of any experimental procedure all waste should be removed as specified below. All contaminated equipment or utensils must be removed and washed and decontaminated or disposed of appropriately.

# RADIATION SAFETY MANUAL

## Section 6: Disposal of Radioactive Waste

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### 6.0 General

Waste disposal is the responsibility of the generator (the person carrying out the procedures with the isotopes) of the waste.

(The appropriate Guideline for disposal of waste in New South Wales is the EPA document "*Environmental Guidelines: Assessment, Classification & Management of Liquid and Non-liquid Wastes (1999)*".)

Residues of radioactive materials and wastes arising from work with such materials are known as radioactive wastes. Such wastes shall be disposed of in accordance with appropriate radiation and waste disposal legislation (EPA).

As a general guide, radionuclides may be discharged from an institution only in quantities low enough such that the waste can be treated according to its constituent category and not as radioactive waste and any other relevant constraints in the Radiation Control Act (1990) and the Regulation (2003) are not exceeded. The current limit is a specific activity of 100 becquerels per gram or ml.

Where more than trace quantities of unsealed radioactive materials are in constant use in laboratories, discharge authorisations for solid, airborne and liquid effluents shall be negotiated with the appropriate local regulatory authorities.

Radioactive wastes of short half-life should be stored in a safe place and allowed to decay, or be diluted so that their activity is reduced to 100 becquerels per gram (or ml.). They can then be discarded as inactive waste according to the EPA category for the actual material constituting the waste (this will usually be "industrial"). Account shall be taken of any longer-lived decay products. Labels and warning signs should be removed from containers before they are consigned as garbage. Nevertheless the University recommendation is that this waste still be transported to a central facility (the “Radiation Bunker” at the Callaghan Campus”) where disposal by a professional waste disposal company will be arranged by the University Radiation Advisor at the generators expense. Material deposited at the Bunker for decay will not be accepted unless labelled with name, date, isotope, estimated time for 10 half lives.

## 6.1 Categories of Waste

The following is an excerpt from the EPA guideline.

**"Section 3.5 Classification of wastes containing radioactive substances"**

Wastes containing any natural or artificial substance that emits ionising radiation spontaneously must be classified on the basis of both their radioactive and other characteristics, according to the stepwise procedure defined below:

1. The radioactivity of the waste must be assessed in accordance with the Radiation Control Act 1990 and the Radiation Control Regulation 2003.
2. If the liquid or non-liquid waste has a specific activity greater than 100 becquerels per gram and consists of or contains more than the prescribed activity of any radioactive element listed in Schedule 1 of the Radiation Control Regulation 2003, whether natural or artificial, it must be classified as *hazardous waste.*
3. If the liquid or non-liquid waste has a specific activity of 100 becquerels per gram or less and/or consists of or contains equal to or less than the prescribed activity of any radioactive element listed in Schedule 1 of the Radiation Control Regulation 2003, whether natural or artificial, then the *total activity ratio* and the *specific activity ratio* must be calculated according to the mathematical expressions given below:

   The **total activity ratio** is calculated using the expression:
   Total activity ratio = (A1 x 10-3) + (A2 x 10-4) + (A3 x 10-5) + (A4 x 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.

   The **specific activity ratio** is calculated using the expression:
   Specific activity ratio = SA1 + (SA2 x 10-1) + (SA3 x 10-2) + (SA4 x 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.

   *Specific activity* is defined in the Code of Practice for the Safe Transport of Radioactive Materials, 1990, which is referenced in clause 23 of the Radiation Control Act 1990.

   *Specific activity* of a radionuclide means the activity per unit mass of that nuclide. The specific activity of a material shall mean the activity per unit mass or volume of the material in which the radionuclides are essentially uniformly distributed.

   The *total activity* of a material means the activity of the whole of the material in which the radionuclides are essentially uniformly distributed (determined using 1-kilogram representative samples of the whole material).

4. If the specific activity ratio, or total activity ratio, is greater than one, then the waste must be classified as follows:

   *Liquid wastes* must be classified as *hazardous waste.*

   *Non-liquid wastes* must be classified as *industrial waste* **unless** other characteristics of the waste mean that it must be classified as *hazardous waste* (for example, it may be classified as *hazardous waste* because it matches another one of the hazardous waste types or streams or it may contain chemical contaminants that will lead to its assessment as *hazardous waste* according to the chemical assessment procedure.

5. If the *specific activity ratio* and *total activity ratio* are equal to or less than one, then the waste must be classified as follows:

6. *Liquid wastes* must be classified according to their other characteristics (ignoring their low-level radioactivity), in accordance with the normal liquid-waste assessment and classification procedure specified in Section 3.

   *Non-liquid wastes* must be classified according to their other characteristics (ignoring their low-level radioactivity), in accordance with the normal non-liquid-waste assessment and classification procedure specified in Section 3."

   Management of radioactive waste at the University of Newcastle requires that at the point of generation the waste must be separated into its various categories. That is Liquid and Solid Waste, High and Low Activity, Aqueous Liquid and Organic Liquid, Radioimmunoassay/125Iodine counting waste.

## 6.2 Aqueous Waste

**Aqueous Waste that can be disposed of by the sink in the Radiation Room**

Low activity aqueous waste, eg tritium, carbon 14, calcium 45, sulphur 35, where the specific activity can be assessed as below 100 becquerels per ml can be disposed of immediately down the designated drain but a record must be maintained of the amounts disposed to the sewer so that a daily/weekly disposal rate can be assessed. Higher activity aqueous waste should be allowed to decay before disposal, eg Phosphorus 32, Iodine 125, Chromium 56. If aqueous waste will decay to an acceptable level within one month, then the waste may be stored in the Building's Radiation Room, however if the time is longer it should be allowed to decay in the local Radiation Bunker. You should contact your Building/Local Radiation Safety Officer for advice. Containers can only be placed in the Bunker if accompanied by a label indicating the name of the waste generator, the laboratory from which the waste came, the isotope, its half life and date when the calculated specific activity of the container will be 100 becquerels or less.

## 6.3 Radio Immunoassy/125iodine Counting Waste

6.3.1 Iodine-125 counting waste (vials) may be disposed of as normal pathology waste as long as the specific activity of the package remains at 100 becquerels per gram or less.
**NB:** Consideration must also be given to any BIOHAZARD implications which may impinge on the disposal of human or animal waste for radioimmunoassay procedures. Guidelines for inactivation of bacteria and viruses must also be followed.

6.3.2 **Radioimmunoassay Waste**

1. Vials and tubes used for gamma counter samples may normally be discarded as non-radioactive waste as the activity is so small as to be negligible. However the calculation of specific activity must still be done to ensure the limit of 100 becquerels per gram is not exceeded. These calculations should be maintained as part of the waste disposal record for that isotope.
2. Do not mix RIA and liquid scintillation waste in the same container.
3. RIA waste should not be labelled as radioactive when discarded.
4. Do not accumulate large quantities of sample tubes as the total activity could approach significant levels.
5. Guidelines for disposal of contaminated waste should be followed if appropriate.
6. The University recommends that all waste be disposed of through a professional waste disposal company who can ensure that all regulations pertaining to the disposal of waste in NSW are properly complied with. This can be organised on a Building/Research Unit basis or be transported to a central location where the University Radiation Advisor will organise disposal at the generator's expense.

## 6.4 Disposal Of Radioactive Waste Via Sewage

As indicated above, low level liquid waste may be discarded via those sinks labelled for the disposal of radioactive materials. Disposal of small amounts of radioactive material via laboratory sinks is possible if the following guidelines are strictly adhered to:

1. Any sink used for disposal of radioactive waste must be clearly marked as such, and only used for that purpose.
2. Only soluble radioactive material may be disposed of via sinks.
3. When waste is disposed of via a sink, it should be flushed with copious amounts of water.
4. Scintillation and other flammable fluids must not be disposed of via sinks as this represents a major fire and explosion hazard. Carrier-free material or material of high specific activity (even though the total activity may be low) should be mixed with a large quantity of non-radioactive carrier before disposal. Where possible, the carrier should be of the same chemical form as the waste. If this is not possible, then the carrier should be in an inorganic form.
5. The specific activity of material that is disposed of in this way must remain at 100 becquerels per ml. or less and a record kept of the calculations and date of disposal.

## 6.5 Long Term Storage

Waste that cannot be disposed of quickly (within 1 month) is no longer able to be handled centrally by the University if transport to the bunker involves road travel on public roads. The limit per package for transport is the same as that for disposal, 100 becquerels per gram. In addition determine whether the package can be classified as an “Excepted Package”. For this classification:

- The activity must be less than that listed in Appendix VIII.
- The surface contamination must be less than 0.4 Bq/cm2.
- The surface dose rate must be less than 5 uSv/h (0.5 mrem/h).
- The surface dose rate must be less than 5 uSv/h (0.5 mrem/h).

(If the package does not comply with the “Excepted Package” criteria, then the transport must comply with the full requirements of Type A or Type B packages. If there is doubt as to the compliance of a package, seek the advice of the Radiation Protection Officer.) Once the material has decayed to a safe level then it can be disposed of, or transported to the central site for disposal. For this purpose a special Radioactive Waste Storage Shed has been constructed and is under the control of the University Radiation Safety Officer/Radiation Safety Advisor, Mr. Bill Bartolo.

Waste that requires professional disposal or storage that is generated on the Callaghan Campus can be transferred to the Radioactive Waste Store. Each item stored must be identified as in 6.6 below and details entered into the register maintained in the Waste Store. The final disposal will be organised by the University Radiation Advisor and if expense is incurred, the appropriate school will be billed.

Disposal of any contaminated waste by a professional waste disposal company is extremely expensive and so as much as possible should be handled ourselves. Particularly with respect to solid waste, eg gloves, tissues, some plastic ware, and aqueous waste. If there is a possibility that it will decay sufficiently for release to the environment within a few months then it should be stored in the Radioactive Waste Shed and then disposed of.

The Radiation Safety Officer/Radiation Safety Advisor has further information on levels of activity that can be released to the environment. If in any doubt, the Radiation Safety Officer/Radiation Safety Advisor must be consulted before proceeding.

## 6.6 Responsibility for Stored Waste

It is the generator's responsibility to ensure any stored waste must be marked with his/her name, the name of the isotope used, the date of the experiment, an estimation of the total amount of activity being stored, half life and the estimated time of disposal. It is the responsibility of the

generator of the waste to make a note of the disposal date and to ensure that it is disposed of after checking levels of activity with the appropriate monitor.

## 6.7 Non-Aqueous (Organic) Liquid Waste

Non-Aqueous (Organic) Liquid Waste cannot be disposed of in the sewerage system. Organic liquid waste should be poured into a designated plastic container in the Building Radiation Room. The container must be marked with each different organic liquid added and the various contaminating radioisotopes indicated. The person who finally fills the container must arrange for its removal to the Radioactive Waste Storage Shed. If no suitable plastic containers are available a limited number are available from the University Radiation Safety Officer/Radiation Safety Advisor. If possible any organic liquid waste containing chlorinated hydrocarbons should be separated from other organic liquids.

## 6.8 Solid Waste

At the point of generation, separation must be made into high and low activity waste. Any glassware or other utensils that are to be reused should be immediately soaked in a decontaminating solution. Disposal of low level waste that is not marked as radioactive can be bagged and if levels are below that of 100 becquerels, can be released to the environment i.e. normal garbage system. Any marked waste or high level waste must be bagged and labelled with:

1. User's Name
2. Date
3. Type of Isotope
4. Level of Activity
5. Half life
6. Expected date of disposal

Again with isotopes that have short half lives that would allow decay to a level permissible for disposal, it is the generator's responsibility to ensure that disposal takes place after checking with a monitor. Bags of waste must be removed from the Radiation Room to the Radiation Waste Store by the generator of the waste.

**WASTE MUST BE REMOVED FROM THE RADIATION ROOM IMMEDIATELY ON COMPLETION OF THE PROCEDURE UNLESS STORAGE FOR DECAY HAS BEEN ARRANGED.**

**THE KEY TO THE RADIOACTIVE WASTE STORAGE SHED ("BUNKER") ON THE CALLAGHAN CAMPUS CAN BE OBTAINED FROM THE UNIVERSITY RADIATION SAFETY OFFICER/RADIATION SAFETY ADVISOR OR THE SECRETARY, SCHOOL OF BIOLOGICAL SCIENCES.**

All material deposited in the BUNKER must be noted on the register in the shed. If it is removed at a later date for disposal then this fact should be noted next to the entry in the Register and a line marked through the entry.

## 6.9 Management of Scintillation Waste including the Scintillation Vials – see link.

## 6.10 Disposal Limits

There are two sets of guidelines for disposal of radioactive waste. The statutory guidelines in NSW are laid down in the Regulations (2003) to the NSW Radiation Control Act 1990. There is also the "*Environmental Guidelines: Assessment, Classification & Management of Liquid and Non-liquid Wastes (1999)*". Both of these provide guidelines for the discharge of any particular radionuclide.

Under the NSW regulations, if there is more than one radionuclide present at any one time, the sum of the quotients (concentration/maximum permissible concentration) for all radionuclides present shall not exceed one as indicated in 6.1 above. This is obviously a difficult calculation to work to and a number of assumptions must be made as to the actual number of radionuclides present and their relative concentrations. However the calculations must be done and recorded.

# RADIATION SAFETY MANUAL

## Section 7: Transport

## Index



### 7.0 Introduction

There is sometimes a need to transport radioactive materials between academic institutions, hospitals, and other medical facilities in such a way that no aspect of public safety is compromised. These guidelines may assist by:

1. providing specific instructions
2. ensuring uniformity of practice and
3. minimising any radiation consequences in the event of a transport accident

The transport of radioactive substances within NSW is governed by the Radiation Control Regulation (1993). That Regulation species that the transport must conform to the detailed requirements contained in the Code of Practice for the Safe Transport of Radioactive Substances (1990), published by the Department of Arts, Sport, the Environment, Tourism and the Territories of the Commonwealth.

The Code of Practice is very comprehensive. Consequently, the guidelines that follow have been extracted and compiled solely for the purpose of this document.

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. These 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 withstand 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/Radiation Safety Advisor is obtained, or the Radiation Control session of the EPA should be contacted for directions.

Please note that these are draft guidelines prepared for consideration by the Radiation Advisory Council of NSW. They have not yet been formally ratified, but are the only guidelines available at the present time.

### 7.1 All Packages

Instructions to Sender for the Transport of Radioactive Materials Between Hospitals, Universities, Research and Other Medical Establishments

1. No radioactive material shall be moved out of any establishment without the prior approval of the licensee responsible for that material.

2. Any procedure used to transport radioactive material from an establishment must be approved beforehand by the Radiation Protection Advisor of the establishment despatching the material.

3. The material must be packaged appropriately:

    - A liquid must be contained in a sealed labelled vial.
    - Place the vial or other source in a labelled shielded (lead etc) container with sufficient liquid absorber. Close the container with a tight fitting lid, and tape.
    - Place the shielded container in another sealable container (paint tin is acceptable), pack well with cushioning material, label “RADIOACTIVE” and give the name and activity of the compound, and the date.
    - Place this sealed container with an outer transport box with cushioning material to prevent movement within the box. Seal and label the box.

4. Measure the surface dose rate and record. Check that there is no contamination on the outer surface.

5. Determine whether the package can be classified as an “Excepted Package”. For this classification:

    - The activity must be less than that listed in Appendix VIII.
    - The surface contamination must be less than 0.4 Bq/cm2.
    - The surface dose rate must be less than 5 uSv/h (0.5 mrem/h)
    - If the package does not comply with the "Excepted Package" criteria, then the transport must comply with the full requirements of Type A or Type B packages. If there is doubt as to the compliance of a package, seek the advice of the Radiation Protection Officer.

6. Radionuclide Consignment Note.

7. Label the package with the name and address of addressee. The package must also bear the sender’s name and address.

8. For transport between different campus sites or hospitals within the Newcastle area a consignment note is not required. Only University staff may be used and then only when they are made fully aware of the nature of the package and what procedures to take in the event of an accident.

9. There must be a description of the goods complying with all requirements of these guidelines taped to the outside of the package.

10. For transport to other institutions outside Newcastle again it would be preferable to use University staff. In most cases this should be the licensee. If there is no alternative to using a transport company. You should contact your local Radiation Safety Officer.

## 7.2 Excepted Packages

### 7.2.1 Instructions to Sender

1. The activity must be less than the value listed in Appendix VIII.
2. The radiation level at any point on the external surface must be less than 5 uSv/h.
3. The non-fixed radioactive contamination on any external surface must be less than 0.4 Bq/cm2

4. 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.
5. The consignor shall include in the transport documents with each consignment, the United Nations Number: "2910" and all items shall be described as: **"RADIOACTIVE MATERIAL, EXCEPTED PACKAGE"**, and shall include the proper shipping name of the substance or article being transported ie **"LIMITED QUANTITY OF MATERIAL".**

### 7.2.2 Package Design

1. The package must retain its contents under conditions likely to be encountered in routine transport.
2. 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.
3. 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.
4. As far as practicable, the outer layer of the package shall be so designed as to prevent the collection and the retention of water.
5. Any features added to the package at the time of transport which are not part of the package shall not reduce its safety.
6. 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.
7. 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.
8. All valves through which the radioactive contents could otherwise escape shall be protected against unauthorised operation.
9. For radioactive material having other dangerous properties the package design shall take into account those properties.

### 7.2.3 Instructions to Transporter

1. A courier approved by the Radiation Advisory Council should be used to transport the package whenever possible. (At this stage there are no approved couriers.)
2. The University's vehicles 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 the Appendix VIX.
3. When the matter is urgent, private cars may be used (insurance provisions may apply). A person is conversant 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.

4. The package must be addressed and delivered to a specific licensed person. It must not be addressed generally to a “School”, nor delivered to some specified “area” or “front desk”. It must be transferred to the custody of a person and certainly not left at an unattended location.
5. The person to whom the package is to be delivered should be advised of the time of despatch and expected delivery time.

### 7.2.3 Type A or Type B Packages

1. Type A or Type B packages must be packaged and labelled in accordance with the Transport Code of Practice.
2. Type A or Type B packages must be transported by carriers approved by the Radiation Advisory Council.
3. Type A packages must not have an activity greater than A1 (for solid or capsule) of A2 (for special form - eg liquid and gases) of the radioactive material (see Appendix VIII).
4. If a package has an activity greater than A1 or A2, it must be packaged as a Type B package.

# RADIATION SAFETY MANUAL

## Section 8: X-Ray Radiation

## Index



## 8.1 X-Ray Analysis Equipment

### 8.1.1 Introduction

Various itemised X-ray equipment are used in universities for the analysis of various materials. This equipment makes use of the phenomena of X-ray diffraction, absorption and fluorescence. In this manual such equipment will be referred to in general as X-ray analysis units or equipment. The dose rate in the X-ray beams from such equipment may be very high and even a brief exposure of any part of a person's body to such a beam could be harmful. Equipment of modern designed incorporates safety features which makes it unlikely that a person using it in the proper manner will be exposed to the intense X-ray beams. Older units still in use may have fewer safety features and may not comply with the requirements of this NH&MRC Code of Practice. All X-ray analysis units, where improperly used, are potential sources of exposure to limited areas of the body, ie eye, skin of the face, fingers and hands, particularly while sample or detector adjustments are made, or when equipment is altered or component parts are replaced.

Reports are occasionally received of actual or suspected over-exposure to limited areas of skin or to the eye by older types of units or due to the practice of inactivating safety features on more recent units. Some workers have had repeated episodes of actual over-exposure. In several cases, the victim was not the person who inactivated the safety feature, but an unsuspecting co-worker.

Exposure to a primary beam from an X-ray analysis unit is considered to be avoidable by using a combination of instrumental safety features, working rules and radiation monitoring.

This manual lays down some general working rules, safety features and some monitoring requirements that should become automatic when using X-ray analysis units. However users must also make themselves familiar with the NH&MRC Code of Practice and the operating manual and safety aspects applying to particular pieces of equipment.

### 8.1.2 Warning Signs, Lights & Labels

1. Every X-ray analysis unit shall be fitted with an illuminated sign or a combination of a sign and a light which is activated only if the X-ray tube is energized and which then indicates that the X-ray tube is operating. This sign shall be legible and readily discernible for at least two metres on all accessible sides of the X-ray analysis unit.
2. Each shutter shall be linked with an illuminated sign or light which is illuminated only when that shutter is open and indicates without ambiguity which shutter is open.
3. Each room, cubicle or area in which an X-ray analysis unit is operated shall have a sign at each entrance stating that an X-ray analysis unit is in that room, cubicle or area.
4. Each room, cubicle or area in which a unit, other than an enclosed unit, is operated shall have at each entrance an illuminated sign or a sign combined with a light which is activated only when the X-ray tube is energized and which then indicates that the X-ray tube is operating.
5. The lights specified in this Code shall be designed to be 'fail safe', ie to de-energize the X-ray if a light fails; alternatively, adequate warning that a light has failed shall be indicated in a clear and unambiguous manner.

6. 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.
7. Partly enclosed units which are partly enclosed by the interlocked or fixed barriers and/or shields shall have displayed on or near them a prominent notice which warns of the hazard of placing any part of the body, such as the hand, inside the barriers or shields.
8. Each X-ray analysis unit shall be clearly labelled to indicate whether it is an enclosed unit, or a partly enclosed unit.

### 8.1.3 General Working Rules for all X-ray Analysis Units

8.1.3.1 Each person who uses an X-ray analysis unit shall avoid exposing any part of the body to a primary X-ray beam. If actual or suspected exposure has occurred the appropriate course of action (see Section 9) should be taken.

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

8.1.3.3 No X-ray tube shall be energised:

1. while outside its protective tube housing, or
2. with an unshielded aperture in the tube head or protective barrier.

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

1. the sample, collimator or crystal, during and after the change or adjustment, is within a shielded enclosure, and
2. the change or adjustment is done by remote means from outside the enclosure.

8.1.3.5 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.

8.1.3.6 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 this Code for enclosed or partly enclosed units. A suggested pre-use safety checklist, which could be posted on the outside of the instrument, follows:

- Visual check of the instrument and signage
- Availability of a survey meter of suitable range
- Checking of interlock switches
- Checking for security of moving parts
- Monitoring of cabinet at full energy setting.

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

8.1.3.8 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.

8.1.3.9 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 Radiation Branch of the EPA (NSW) or unless the X-ray rube is wholly enclosed by the tube housing with all apertures completely covered by interlocked shutters and/or fixed covers.

8.1.3.10 If under prior approval of the Radiation Branch of the EPA (NSW) the X-ray analysis unit is operated with an interlock inactivated or part of its enclosure removed exposing the primary beam, the following rules shall be applied:

1. The number of persons who carry out the alignment of a camera or sample in an X-ray beam, or who make any adjustment or alteration to the analysis equipment while the X-ray tube is energized, shall be the minimum necessary to carry out the operation safely.
2. An experienced person not engaged in the operations specified in 6.2.10.1 must observe the procedures and warn each operator performing them of any operation which might lead to any part of the body being exposed to a primary beam or any excessive level of leakage radiation or scattered radiation.
3. When the X-ray tube is energized, access of non-essential personnel to the room containing the unit shall be prevented by physical barriers. A sign warning of the operations in progress shall be placed at each entrance to the room containing the unit.

### 8.1.4 Monitoring

Radiation monitoring is an essential aid in the control of radiation hazards in the vicinity of X-ray analysis units. However, the accurate measurement of radiation from these units is often difficult and a person seeking to do such a measurement needs specialised 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:

8.1.4.1 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.

8.1.4.2 Personnel Monitoring

Localised 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. The following requirements for personal monitoring are therefore recommended:

8.1.4.3 Monitoring of 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:

8.1.4.5 If provided with meter indication, the meter shall be calibrated in either:

1. 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 volumes of the detector indicated on the instrument, or
2. 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.

8.1.4.6 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.

8.1.4.7 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:

**Monitoring**

**Type of Unit:**
- Enclosed; or
- Partly Enclosed.

**Frequency:**
- Quarterly
- Monthly

In addition, partly enclosed units should be examined for hazardous situations and all safety features checked at least once in each week. For units that do not comply with Section 5 of this Code see 6.4.8.2.

8.1.4.8 Special radiation monitoring shall also be conducted in the following circumstances:

(a) installation of the X-ray analysis units,
(b) replacing an X-ray tube,
(c) any modification or reassembly of any shielding component.
(d) any actual or suspected over-exposure, and
(e) after any extended period of non-use.

This monitoring should include the use of radiographic film or collimated detector to determine accurately the location and extent of any cracks or defects in the shielding.

8.1.4.9 Adequate records shall be kept of all radiation monitoring and examinations for hazards and each entry should include a description of the equipment arrangement and any action taken as a result of the monitoring or examination.

## 8.2 Diagnostic X-Ray Equipment

### 8.2.1 Introduction

The University owns five (5) general X-ray units (2x Philips Diagnost 50's general x-ray units, in HC08, 1x Philips Diagnost 50 Cosmos general x-ray unit and 1x Bennet tomographic general x-ray unit in HC10 and 1x Philips Diagnost 50 general x-ray unit in HC12) along with a Fuji Computed Radiographic processing unti and associated image plates as well as a number of radiographic phantoms. Apart from the 12 year old Bennet unit the remaining 4 units are registered with the DECC as compliant for imaging patients. The Bennet unit can be safely used for imaging radiographic phantoms for skills development of the student body. No clinical patients are imaged but a number of research projects, many involving patients, are conducted in this facility. The facility is one of the most modern available for the education of Medical Radiation Science Students in Australia.

In May 2009 the University will be commissioning a new Positron Emission Tomography (PET) unit in HC21/23. This unit will be dedicated to teaching and research activities within the Faculty of Health and overseen by the School of Health Sciences, Medical Radiation Science, Nuclear Medicine group.

The X-ray facilities housed in the Hunter Building are primarily involved in the undergraduate teaching (skills development) of the BMRS Diagnostic Radiography student cohort, but are increasingly being involved in a number of research activities.

### 8.2.2 Licensing of Operators

The above units are housed and operated under the auspices of the Discipline of Medical Radiation apart from the animal x-ray unit housed in the MSB Animal Rooms. Only members of this Discipline and the University Veterinarian with the appropriate licences may operate these units or supervise the operation of these units.

### 8.2.3 Warning Signs and Labels

All the warning signs (both visual and audible) as recommended by the NH&MRC Codes of Practice must be in place and operating. Specifically, each unit should be fitted with a combination of warning sign and light which is illuminated when the unit is energised and an alarm audible when the unit is energised and the shutter open. There should be a fail-safe system in operation in which the unit will fail to energise if either the warning light or alarm fails to operate.

There should be a warning sign and light outside the room housing the X-ray units which is illuminated when any of the units are in operation.

### 8.2.4 Shielding

There shall be appropriate shielding and clothing, eg lead aprons, available for the protection of operators of all diagnostic X-ray machines. This applies to staff and students on site and students on placement as part of course requirements.

### 8.2.5 Staff & Students

Staff and students operating diagnostic X-ray machines are required to wear personal radiation monitors and be part of an organised badge system (see Section 3).

### 8.2.6 Protective Barriers

The equipment shall be housed such that:

(a) The controls of the apparatus are located behind a fixed protective shield, situated within the room where the radiation apparatus is housed. The shield shall be not less than 2.1m in height and arranged so that the radiation emitted by the radiation apparatus has scattered at least twice before it enters the area behind that screen occupied by the operator.

(b) The control area should not be situated in the direction of the primary beam, or part thereof, and it should be a minimum distance of two metres from the X-ray tube assembly.

(c) The exposure switch shall be arranged so that it cannot be operated outside the shielded area.

### 8.2.7 Other Protective Barriers

(a) A protective apron and protective gloves with a shielding value of not less than 0.3mm lead equivalent at 150kVp shall be provided for the operator's use if the operator is not able to stand behind the protective barrier.

(b) All protective clothing shall be clearly and indelibly marked with the following information:
- manufacturers' name or trademark;
- lead equivalence at a stated potential difference;
- date of manufacture;
- single or laminated material;
- size.

(c) Handling and storage of protective clothing shall be in strict accordance with the manufacturer's recommendations. Most shall be provided to ensure that aprons may be hung to prevent cracking of the protective material.

### 8.2.8 Exposure Indication Warning Signs

(a) A radiation warning sign must be displayed on the outside of the entry doors to the room in which the apparatus is installed.

(b) The radiation warning sign must conform with those requirements of Australian Standard

AS1319-1983 “Safety Signs for the Occupational Environment” published by the Standards Association of Australia relating to caution (warning) signs.

(c) The sign shall be illuminated whenever the x-ray tube is placed in the preparation mode prior to exposure.

### 8.2.9 The X-Ray Assembly and Support

(a) The x-ray tube assembly shall be supported and remain stationary when placed in position for radiography, except tomography and other procedures in which it is a requirement that the x-ray tube assembly move in a predetermined manner.

(b) Markings on tube assemblies and beam limiting devices shall be in English and clearly visible.

(c) X-ray tube assemblies shall bear the following markings on the outer side of the tube housing in a visible position:

- name or trademark of manufacture of X-ray tube
- type of model number and serial number of X-ray tube insert
- name or trademark of X-ray tube housing
- type number and serial number of X-ray tube housing
- maximum potential difference of X-ray tube housing
- nominal value of inherent filtration and any added filtration of the tube housing expressed in equivalent aluminium thickness at a specific kVp
- size of nominal focal spot(s)
- position of focal spot(s)
- position of anode

### 8.2.10 The Beam Limiting Device

(a) An adjustable multi-leaf collimator shall be fitted to the x-ray tube assembly, and the extent of the diagnostic radiation beam shall be defined by a light beam.

(b) The area illuminated by the light beam collimator shall be effectively coincident with the irradiated area. The total misalignment of any edge of the light field with the respective edge of irradiated field shall not exceed 1% of the distance from the focus to the image receptor. This shall be so for both broad and fine focus.

(c) The light beam collimator should be capable of rotation of not less than ± 45o from the central position.

(d) The centre of illuminated area shall be indicated.

(e) The adjustable area selectors of the light beam collimator shall be provided with scales that relate the selected area to the focal spot-film distance.

(f) Beam limiting devices shall bear the following markings:

- name or trademark of the manufacturer or supplier
- type of model number and serial number of device
- nominal value of inherent filtration of the collimating device and any added filtration expressed in equivalent aluminium thickness at a specific kVp

### 8.2.11 Radiation Leakage

(a) The x-ray tube shall be enclosed in a housing in such a manner that their air kerma from leakage radiation measured at a distance of 1 metre from the focus of that tube in one hour, averaged over an area not larger than 100cm2, shall not exceed 1.0mGy.

(b) Diaphragms, cones or collimators used to limit the primary beam to the area of clinical interest shall be constructed so that, in combination with the tube assembly, they comply with the leakage radiation limits set out in paragraph 8.2.7 (a).

### 8.2.12 The Exposure Switch

(a) The exposure switch shall have a circuit closing contact which:

- can be maintained only by continuous pressure
- makes it impossible to make repeat exposures without releasing the switch
- makes it possible to interrupt the exposure at any stage of a programmed exposure

(b) The exposure switch shall be:

- designed so that it is protected against accidental operation, and
- arranged so that it cannot be operated outside a shielded area.

### 8.2.13 Indication of Exposure Factors

The exposure factors which have been set by adjusting the control setting shall be provided and clearly indicated at the control panel.

# RADIATION SAFETY MANUAL

## Section 9: Radiation Monitoring Equipment

9.1 It is essential that any laboratory classified as a medium level laboratory (Section 5.3) is supplied with the appropriate radiation monitors for the type and energy window of the isotopes being used.

9.2 The Radiation Control Act NSW (1990) requires that such devices should be properly maintained and serviced regularly and that they be calibrated annually. A record should be maintained of the servicing and calibration of each instrument.

A service and calibration service on an annual basis has been organised by Trevor White of the Health Faculty Workshop in the Medical Sciences Building. This service will be billed to the user. Enquiries should be addressed to Trevor.White@newcastle.edu.au

9.3 Modern instruments are often self calibrating and/or may come with a small test spot that delivers known level of radiation (CPS) at a given distance, if the instrument is operating normally. This test should be performed each time the instrument is used, but should be recorded at monthly intervals. This does not replace the need for formal annual calibration and servicing.

### List of Radiation Monitoring Equipment

| Type of Instrument | Detector | Manufacturer / Supplier | Location Contact Person |
|---|---|---|---|
| Area Survey / Contamination Meter | Scintillation X-Ray Probe Type 542B 4KeV - 100Kev | Mini Monitor Neo Medix Series 900 | X-Ray Centre, Aviation Building, J. Zobeck |
| Area Survey / Contamination Meter | GM Tube Type s.10 E Beta detector | Mini Monitor Neo Medix | Geology, R. Bale |
| Area Survey / Contamination Meter | GM Tube X-Ray Probe 15KeV - 60KeV | Mini Monitor Neo Medix | Cancer Research, David Maddison Building, D. Dorahy |
| Area Survey / Contamination Meter | GM Tube Weak beta 2.2 -5.5KeV | Mini Monitor Neo Medix | Cancer Research, David Maddison Building, D. Dorahy |
| Area Survey / Contamination Meter | GM Tube Strong beta 0.05 - 1.25MeV | Mini Monitor Neo Medix | Cancer Research, David Maddison Building, D. Dorahy |
| Area Survey / Contamination Meter | GM Tube Strong beta 0.05 - 1.25MeV | Mini Monitor Neo Medix Sales quos | Medical Biochemistry, Life Sciences Building, L. Herd, P. Jarvie |
| Area Survey / Contamination Meter Vicroreen with Pantake detector 489-110 (2 instruments) | GM Tube Beta above 70 KeV Gamma above 6 KeV | Vicroreen Gammasonics | Medical Biochemistry, Life Sciences Building, L. Herd |
| Area Survey / Contamination Meter Type 540 | GM Tube X-Ray detector 100KeV | Mini Monitor Neo Medix | Clinical Pharmacology, New Med II, P. Brent |

| | | | |
|---|---|---|---|
| Area Survey / Contamination Meter (* instruments) | GM Tube Beta<br>0.66 MeV Gamma<br>0.05 - 2.5 MeV | Mini Monitor Neo Medix Series 900 | Pathology, David Maddison Building,<br>G. Pang |
| Area Survey / Contamination Meter | GM Tube Beta<br>above 200 Kev Gamma<br>above 2 MeV | Vicroreen Thyac III Gamma | PVC Office, Faculty of Science & Information Technology,<br>D. Kay |
| Area Survey / Contamination Meter | GM Tube<br>900S 0.05 - 1.25 MeV | Mini Monitor Neo Medix | Biological Sciences,<br>D Kay |
| Area Survey / Contamination Meter | GM Tube X-Ray Probe (low gamma)<br>Type 5.42 | Mini Monitor Neo Medix | Biological Sciences,<br>J. Patrick |

# RADIATION SAFETY MANUAL

## Section 10 : Accident, Spill and Decontamination Procedure

### Index



### 10.1 Legislative Requirements

Within the meaning of the Radiation Control Act (1990) certain accidents are taken to be radiation accidents. These must be formally reported to the EPA.

**10.1.1** 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 and unexpected emission of radiation (such as 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 a 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 premises or the environment may have become contaminated within the meaning of section 21 of the Act.

**10.1.2 General Working Rules for all X-ray Analysis Units**

For the purposes of this Regulation, a radiation accident is to be treated as having occurred if there is an occurrence that involves:

(a) the misuse of radiation apparatus;

(b) administration of a therapeutic dose of radiation from radiation apparatus or a sealed radioactive source which differs from the prescribed treatment dose by more than 10 per cent;

(c) the unintended administration of radiation as a result of a malfunction of radiation apparatus.

### 10.2 Radiation Accident Procedure

In the case of accidental irradiation or accidental contamination or ingestion or radioactive material by any member of staff, student or a visitor, the following procedure should be followed:

**10.2.1** The person involved shall report the incident to their immediate supervisor, who shall report it immediately to the School/building Radiation Safety Officer. If external contamination is involved, the contaminated person must be encouraged to remain, if practicable, in the immediate area to prevent spread of contamination.

**10.2.2** The School/Building Radiation Safety Officer shall make an initial assessment of the situation and, unless the incident is of a minor nature, and in case of any doubt, the University Radiation Safety Officer/Radiation Safety Advisor must be immediately notified. It is sometimes difficult to reconstruct an accident. It is therefore recommended that all persons involved write a brief (1 paragraph) report of the accident situation as soon as feasible after the incident. It should be encouraged that these reports are written independently and without discussion of the persons involved.

**10.2.3** The School/Building Radiation Safety Officer investigates the situation, recommending any immediate action that may be taken, such as decontamination.

**10.2.4** Each situation shall be considered separately, but in every case an estimate shall be made as soon as possible of any personal radiation dose as a result of the incident. If this dose exceeds 0.5 Gy, then the person is required to be admitted to hospital and placed in isolation. This would be an extreme situation and unlikely to occur at the University of Newcastle with the levels of isotopes currently used. A Radiation Oncologist and Haematologist should be consulted in such cases.

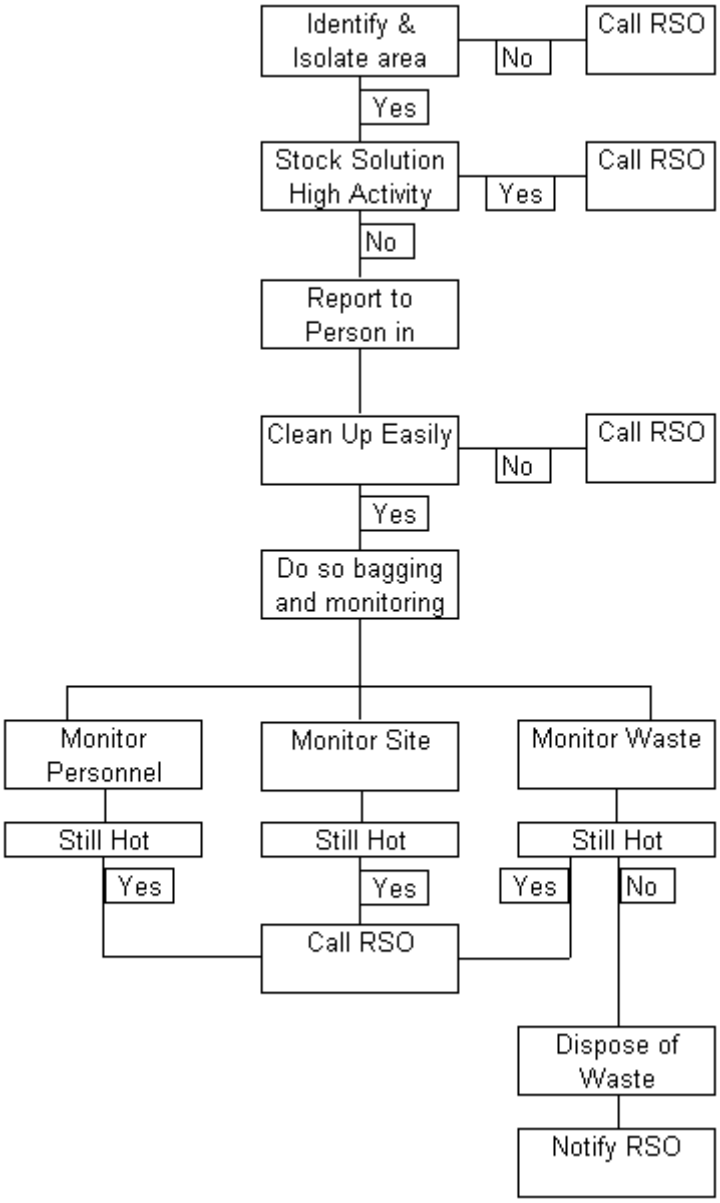
**10.2.5** In appropriate cases the local Radiation Safety Advisor shall carry out an investigation and produce a report to the University Radiation Safety Officer/Radiation Safety Advisor. Incidents involving radiation are subsequently presented to the Radiation Safety Committee for consideration. Guidelines on reporting of radiation incidents are to be found in Section 10.

**10.2.6** Any recommendations made as a result of the incident and approved by the Radiation Safety Committee and Occupational Health and Safety Committee and forwarded to the section concerned as soon as possible and the University Radiation Safety Officer/Radiation Safety Advisor may, at some later date, make a follow up investigation to discuss implementation of any recommendations.

## 10.3 Radiation Spills - Action To Be Taken

**10.3.1** Action Flow Chart - Remember to report the spill to the supervisor or section/laboratory manager or Building RSO.

**Radiation Spills Action Flowchart**




"Hot" is defined as significantly above background, given knowledge of the isotope, specific activity and characteristics of the measuring instrumentation, and type and energy of the radiation being measured. "Disposal of Waste" refers to storage in the appropriate "Bunker" to allow decay.

### 10.3.2 Post Mortem

Please examine your procedure - was the spill avoidable? Unless the spill is very minor, the School/Building Radiation Safety Officer must be notified and an Accident Form completed.

## 10.4 Decontamination Procedures

Decontamination is the removal of radioactive contamination from animate and inanimate surfaces. If contamination is found it must be removed at once. High specific activity isotopes can be held on a surface by ionic attachment, or by physical absorption or diffusion into cracks. Often a fresh spill on a clean and polished surface can be washed off without detectable residual contamination, where if it were allowed to react with the surface it might need drastic action to remove it. This is a very good reason for monitoring

a working space immediately after using radioactive material, and for removing contamination associated with spills as quickly as possible.

### 10.4.1 Environment

Although special decontaminations involving the use of acids, alkalis, complexing agents and ion exchange materials are available, it is best to first try simple methods such as soap and water (preferably distilled) or detergent unless a special decontaminant is specifically indicated.

In the event of a minor spill involving no radiation hazard to personnel, the operator (wearing rubber gloves) should proceed as follows:

Mark out the area with radiation marking tape and then for:

***Wet spill:*** the liquid should be carefully wiped up with blotting paper or similar material.

***Dry spill:*** the material should be carefully wiped up with absorbent tissue moistened with a 5% solution of glycerine in water. In the case of very active and toxic materials, which also present an ingestion hazard, a suitable face respirator should be worn.

All papers used in cleaning should be placed in a radiation waste receptacle and the affected areas monitored. Decontamination should be carried out until no further reduction in radiation levels, as checked by the Radiation Officer, is being achieved, provided that the contamination level is then below the maximum permissible.

After completion of all operations, the area must be checked with radiation monitoring equipment or, in the case of 14C and 3H, with a swab which can then be counted in the Scintillation counter.

**IF THERE IS ANY DOUBT CONCERNING THE ABOVE PROCEDURES, ADVICE AND RULINGS SHOULD BE SOUGHT FROM THE SCHOOL/BUILDING RADIATION OFFICER.**

### 10.4.2 Personnel

(i) Before using more vigorous techniques that risk breaking the skin and allowing radioactive material to enter the body, covering the contaminated area with plastic wrap( or plastic gloves if on the hand) for a period of time may allow sweating to loosen the contamination which can then be removed by gentle washing. This period can be up to 24 hours. The skin dose during that period is likely to be small and the risk of breaking the skin is avoided.

(ii) Wash gently with soap and water, avoiding contamination of the eyes and mouth. Do not scrub to avoid irritating the skin and "rubbing in" the activity. Monitor with a portable survey meter until the count rate is less than 1000 cps (or the exposure is less than 10 microgray/hr with the detector at a point close to the contaminated region of skin. These levels must be interpreted along with knowledge of the isotope concerned, its biological implications, its specific activity and type of energy, and the characteristics of the measuring instrumentation. If in doubt the Building RSO or University RSO should be contacted for advice.

(iii) If this fails, a paste of fuller's earth or Kaolin may be applied and subsequently washed off the soap and water.

(iv) If this fails, try E.D.T.A. solution (a chelating agent) followed by a nail brush, soap and water.

(v) As a last resort, immerse the hands or swab affected skin in saturated potassium permanganate solution, rinse in water and remove stain with 5 per cent solution of sodium bisulphite.

***Mouth*** - wash out with hydrogen peroxide solution (1 tablespoonful of 10 volume hydrogen peroxide to a tumbler of water) several times.

Radioactive material in the ***eyes or nose*** - solid or liquid. Irrigate with saline (0.9 per cent common salt solution). If this solution is not available, use tap water. Care must be taken to avoid swallowing contaminated material.

***Contamination of a Wound*** - wash under a tap with copious quantities of water and encourage bleeding. If the wound is on the face take care not to contaminate the eyes, mouth, or nostrils. Next, wash the wound with soap and water and apply disinfectant and first aid dressing.

**All accidents involving significant contamination of personnel must be reported immediately to the University Radiation Safety Officer/Radiation Safety Advisor through the School/Building Radiation Officer.**

All material used in decontamination or treatment of an injury must be collected and bagged and labelled for disposal once treatment has been completed.

**Note:** All materials listed above should be stored in easy access in the Radiation Rooms (Medium Level Laboratories).

## 10.5 Reporting to the Environment Protection Authority

Incidents which require notification to the EPA Radiation Control should be determined under the guidelines drawn up by the EPA. In the meantime, any incident where any of the following limits are exceeded should be reported to the Radiation Control Section of the EPA by the University Radiation Safety Officer/Radiation Safety Advisor as soon as possible, but in any case, less than thirty days following the incident.

**10.5.1** Exposure of an individual to radiation in excess of the maximum permissible annual dose for the relevant category of staff.

**10.5.2** Concentrations of radioactive material in an unrestricted area in excess of 10 times the limit prescribed in the Radiation Control Act 1990 for the particular radionuclide.

Comments on the content of this document should be reported to the Associate Director, Health & Safety Team, Human Resource Services.

# RADIATION SAFETY MANUAL

## Section 11: Record Keeping and Responsible Officers

The following list provides details of records which need to be kept and the staff members who are responsible for them. These records will be checked on an annual basis by the University Radiation Safety Officer/Radiation Safety Advisor.

| Record/Register | Person Responsible |
|---|---|
| Laboratory use of isotopes (purchase details, place of storage, users record of use and method of disposal) | **Licence Holder** |
| Exemption Details | **Licence Holders** |
| Storage Register | **Licence Holders, School/Building Radiation Safety Officer** |
| Disposal Record - [for each disposal point (sink), method (dilution) and date of disposal for each isotope, ie it must be possible to inform the Water Board how much of a particular radionuclide has been disposed via the sewer and in what dilution.] | **Licence Holders** |
| Register (Reportable Accidents) | **University Radiation Safety Officer/Radiation Safety Advisor** |
| Records of servicing and calibrating of equipment | **Licence Holder** |
| Record of use of X Ray units (diffraction and therapeutic) | **Licence Holders** |
| Central Register of Amounts of Radioisotopes | **University Radiation Safety Officer/Radiation Safety Advisor** |
| Personnel Monitoring Records | **School/Building Radiation Safety Officer** |

# RADIATION SAFETY MANUAL

## Section 12: Radiation and Pregnancy

12.1 Ionising radiation, being damaging to tissue in large enough quantities, is potentially harmful to the foetus. The risks however, for diagnostic and occupational levels of radiation exposure, are very small. The greatest risk of mental retardation, occurs in the 8-16 week period of a pregnancy, ie after most pregnancies are known. The risk of all adverse effects is of the order of 1 per 10,000 per mGy dose to the foetus, ie a risk of approximately 0.01%/mGy. This compares to normal occurrence of congenital defects of approximately 5%.

12.2 Female staff working with radiation or radioactive material are naturally concerned as to the well-being of their foetus if they fall pregnant and continue to work in the same situation until the pregnancy is recognised. The National Health and Medical Research Council considers that separate dose equivalent limits are not necessary, assuming that a pregnancy would not go unrecognised for more than two months. When a pregnancy is confirmed, however, arrangements should be made to ensure that the woman works only under such conditions that it is most unlikely the exposures during the remainder of the pregnancy will exceed 3/10ths of the pro-rata annual dose equivalent for radiation workers. Staff working in areas where radiation is used routinely may request special radiation exposure monitoring (usually TLD) whilst they remain at work. (Contact the Building/School RSO for details).

12.3 Exposure of the embryo or foetus of a patient who is subsequently found to be pregnant often creates unnecessary worry in the mind of the patient or her medical practitioner. In fact, the risk of radiation exposure, even at relatively large levels, is very small compared to the normal risks of pregnancy. Information in the literature suggests that absorbed doses of 20 mGy would pose no risk and unqualified reassurance may be given to the patient. This is not to say, however, that doses of this order may be deliberately administered to a pregnant patient. It must be stressed that this applies only to accidental exposures, where the alternative may be termination of the pregnancy - a quite unwarranted step in nearly all cases.

All cases of accidental irradiation of a foetus or embryo should, for the sake of all concerned, be referred to the University Radiation Safety Officer/Radiation Safety Advisor or a radiologist.

12.4 Staff who are concerned about their own circumstances are welcome to contact the University Radiation Safety Officer/Radiation Safety Advisor for further information.

# RADIATION SAFETY MANUAL

## Section 13: Non-ionising Radiation

### Index



## 13.1 Introduction

Non-ionising radiation is distinguished from ionising radiation, the subject of the rest of the manual, by the different mechanism of interaction with matter. Whereas ionising radiation ionises atoms within the tissue, non-ionising radiation interacts differently with human tissue, for example by generating heat. Although x-rays and gamma rays are part of the electromagnetic spectrum, the term "non-ionising radiation" (NIR) encompasses wavelengths from visible light to microwave and also includes ultrasound. For the purposes of this manual, the only NIR radiations discussed are lasers, ultraviolet, microwave and ultrasound.

Supervisors and staff using lasers of classifications III (a and b) and IV, should make themselves familiar with the Australian Standard - Laser Safety (ASS 2211-1991).

## 13.2 Lasers

### 13.2.1 Introduction

The word "LASER" is actually an acronym for "Light Amplification by Stimulated Emission of Radiation" and is commonly applied to devices which emit an intense, coherent and highly directional beam of "light". Laser radiation covers the infra red, visible and ultra violet regions, depending on the type of laser. The most common interaction with tissue is production of heat which, because of the highly intense nature of the laser beam and its ability to be finely focused, can be generated in very large quantities, sufficient to evaporate tissue and cause a large amount of damage in a very short time.

Lasers are divided into classes, depending on the power output and the risk of damage from accidental exposure. The classes are:

*Class 1* - intrinsically safe

*Class II* - low power devices emitting visible light - not completely safe, but the blink reflex will protect the eye

*Class IIIa* - similar to Class II, except that, if the beam is focused onto the eye by, say, binoculars, the beam could be hazardous

*Class IIIb* - either the blink reflex is not fast enough to prevent damage, or the beam is invisible and therefore the blink reflex cannot work

*Class IV* - high power devices capable of causing immediate injury to the eye or skin - diffuse reflections may be hazardous

**Most medical lasers are in Class IV, the most hazardous.**
The principal hazard is damage to the eye. Laser radiation in the visible and near infra red wavelength regions can penetrate the eye and damage the retina, possibly permanently, while ultraviolet laser radiation and far infra red radiation can damage the surface of the eye. Most lasers used in medicine are very high power devices and damage can occur in a fraction of a second far quicker than the eye can blink to shut off the beam. The hazard arises mostly from accidental reflections of the beam from shiny objects.
For staff using lasers it must be stressed that damage is most likely immediate and often permanent - thus the operating rules which are given for each installation (local rules) must be understood and adhered to by all staff involved.

### 13.2.2 Administrative Arrangements

Overall control of safety aspects of the use of lasers within The University of Newcastle rests with the Occupational Health and Safety Committee (OHSC). The Radiation Committee shall recommend and maintain policies and regulations for the control of laser hazards.

The Vice-Chancellor, through the OHSC, shall appoint a Laser Safety Officer (LSO), the OHSC to have routine authority for supervision and control of laser hazards. The range of duties of the LSO shall be similar to those for the University Radiation Safety Officer/Radiation Safety Advisor.

One person at each installation shall be designated as the laser supervisor, who shall be responsible for day-to-day safe use of the laser.

In the absence of licensing under State Radiation Regulations as with ionising radiation, ALL WISHING TO OPERATE LASER UNITS OF CLASS IIIB AND ABOVE SHALL BE REGISTERED WITH THE OCCUPATIONAL HEALTH AND SAFETY COMMITTEE TO DO SO. NO PERSON WHO IS NOT REGISTERED SHALL OPERATE ANY LASERS OF CATEGORIES IIIB AND IV. Registration will require training in both the medical and physics/safety aspects of lasers.

All laser facilities shall be registered and be surveyed for safety hazards before operations can commence. The Laser Safety Officer shall be consulted in the planning stages of any new laser facility.

All staff who are required to work with any laser should receive basic training on the hazards of lasers and safe working practices. This training could be provided by the Laser Safety Officer or other persons competent to do so.

All staff who are required to work with a class IV laser shall undergo a baseline eye examination before commencing work with the laser followed by 2 yearly examinations and/or an examination on leaving the institution. Further examinations shall be performed in the case of a known or suspected accident/incident.

### 13.2.3 Responsibilities

**Laser Supervisor**

The laser supervisor shall be responsible for:

1. only permitting operation of the laser when there is adequate control of laser hazards.
2. liaison with the laser safety officer on such matters as hazard evaluation and medical surveillance.
3. reporting of known or suspected accidents or incidents and ensuring that medical examinations of staff involved are arranged.

4. ensuring that all new employees required to work with the laser are adequately instructed on safety measure.
5. ensuring that there is available to staff an adequate supply of protective eyewear for the particular laser in use.

**Employees**
Employees are responsible to some degree for their own safety. In particular, they shall not work with or near a laser unless authorised to do so and shall at all times comply with safety measures prescribed by the laser supervisor and the Safety Officer. Further, if they know or suspect that an accident or incident has occurred, they shall immediately inform the laser supervisor and complete a mishap report.

### 13.2.4 Medical Surveillance

As mentioned in Section 13.2.2, many staff working with Class IV lasers are to have a baseline eye examination prior to commencement of work with the laser and at termination as well as twelve monthly routine examinations. In case of accidental exposure, a further examination should be performed.

Australian Standard AS2211-1991 outlines the required ocular examinations, including a test of visual acuity, central visual fields and fundus examination. Any deviation from acceptable performance will require identification of the underlying pathology by testing as deemed appropriate by the examining medical officer.

**Ocular History**
The past eye history and family history shall be reviewed. Any current complaints concerned with the eyes are noted. Inquiry should be made into the general health status with a special emphasis upon systematic diseases which might produce ocular problems. The current refraction prescription and the date of the most recent examination should be recorded.

**Visual Acuity**
Visual acuity for far and near vision should be measured with some standardised and reproducible method. Refraction corrections should be made if required for both distant and near test targets. If refractive corrections are not sufficient to change acuity to 20/20 (6/6) for distance, and Jaeger 1- for near, a more extensive examination is indicated.

**Macular Function**
A Humphrey's automated visual field test should be performed as a screening test, ie not the full examination.

**Contrast Sensitivity**
Contrast (or glare) sensitivity should be documented by the Arden sine wave patterns or similar acuity tests which include low constant images.

**Examination of the Ocular Fundus with an Ophthalmoscope**
The macula should be checked by a medical officer.

**Examination following Suspected Accidental Exposure**
If it is suspected that an accidental eye exposure has occurred, the incident should be reported to the laser supervisor immediately, and arrangements made for medical examination. The case should be handled as an eye trauma, and the necessary examinations determined by the John Hunter Eye Clinic.

## 13.3 Ultraviolet Radiation

Ultraviolet (U/V) radiation can cause a number of hazards, the most grave being the induction of skin cancer. Exposure is most likely to occur from the sun, and it is well known that there is a link between sunlight and skin cancer. In fact, the permissible weekly levels of occupational exposure to UV are exceeded in a few hours of exposure to the summer sun!

Ultraviolet radiation is used mainly in the University to view electrophoretic gels for and for disinfection of fume hoods. It is commonly divided into three wavelength bands, UV-A (400-315nm), UV-B (315-280 nm) and UV-C (280-100 nm). Most medical applications of ultraviolet are in the UV-A and UV-B regions.

The hazards to staff are to the eye and to the skin. No person should look at a UV source without eye protection. As mentioned, it is well known that excessive UV irradiation, particularly to fair skin, can be carcinogenic. The operator may need to wear UV shielding goggles to protect the eyes. Skin protection can be achieved simply by clothing made from tightly woven fabric.

There is no monitoring method commonly available for ultraviolet radiation and staff must follow any procedures laid down for use of ultraviolet in their department.

## 13.4 Microwave and Radio Frequency (RF) Radiation

This is also electromagnetic radiation covering the frequency range from 300 kHz - 300 Mhz (RF) and 300 Mhz - 300 Ghz (microwave).

Microwave radiation appears in Universities mainly in microwave ovens but also there are some microwave communication transmitters. Its effect on tissue is mainly heating, and the organ most at risk is the eye. Microwave ovens should be tested regularly for leakage around the door, the most likely source of accidental exposure. This is the responsibility of the Lab Supervisor.

Radiofrequency radiation also has a heating effect, but the risk over the whole frequency range is not fully understood. The maximum recommended exposure levels are in the range 1-5 mW/cm2.

## 13.5 EXTRA LOW FREQUENCY (ELF) RADIATION

ELF radiation concerns mainly power frequencies, ie normal domestic electricity supply. Here we are concerned with electric and magnetic fields. The electric field is that which (at high levels) generates sparks, similar to static electric fields. The magnetic field is normally not perceptible, although very high levels can cause visual or cardiac effects. The effects of low level ELF radiation are difficult to measure since the incidence appears to be very low.

Although power lines cause most public concern, the fields from VDUs the electron microscope and domestic appliances such as hair dryers and vacuum cleaners can be higher.

There is no known hazard from ELF radiation in the normal University working environment.

# RADIATION SAFETY MANUAL

## Section 14: References

This is not meant to be a complete list, but includes specific references used in the manual, and some useful additional material.

### General


- *An Introduction to Radiation Protection* (3rd ed.), Martin A and Harbison SA, Chapman & Hall, London, 1986
- Australian and New Zealand Standard AS/NZ 2243.4 1998 *Safety in Laboratories. Part 4 - Ionising Radiations*. Standards Association of Australia
- Australian and New Zealand Standard AS/NZ 2211.1 2004: *Safety of Laser Products, Part 1: Equipment classification, requirements and user's guide*
- *Introduction to Health Physics* (2nd ed.), Cember H, Pergamon, NY, 1983
- *Low-Level Radiation Effects - A Fact Book*, Bertrand Brill A (ed.), Society of Nuclear Medicine, NY, 1982
- *Non-Ionising Radiation Protection*, Suess MJ (ed.), WHO Regional Publications European Series No. 10, WHO, Copenhagan, 1982
- *NSW Radiation Control Act 1990*
- *NSW Radiation Control Regulation (2003)*
- *Code of Practice for the Safe Transport of Radioactive Substances (1990)*
- *National Standard for limiting occupational exposure to ionising radiation*: National Occupational Health and Safety Commission publication 1013 (1995)
- NSW Radiation Series No. 5: *Recommendations for Radiation Safety Officers and Radiation Safety Committees*
- *Environmental Guidelines: Assessment, Classification & Management of Liquid and Non-liquid Wastes (1999)*: NSW EPA publication
- *Minimum Standards and Safety Requirements for Ionising Radiation Apparatus used for Diagnostic Medical, Dental and Veterinary Purposes*. Draft 2, August 1994, NSW Environmental Protection Authority


### NH&MRC Publications


- Recommended Radiation Protection Standards for Individuals Exposed to Ionising Radiations (1980)
- Recommendations relating to the discharge of patients undergoing treatment with radioactive substances (1983)
- Code of nursing practice for staff exposed to ionising radiation (1984)
- Administration of Ionising Radiation to Human Subjects in Medical Research (1984)
- Code of Practice for Protection Against Ionizing Radiation Emitted from X-Ray Analysis Equipment (1984)
- Code of Practice for the Disposal of Radioactive Wastes by the User (1985)
- Recommendations for Minimising Radiological Hazards to Patients (1985)
- Code of Practice for the Safe Handling of Corpses Containing Radioactive Materials (1986)
- Code of Practice for Radiation Protection in Dentistry (1987)
- Code of Practice for the Control and Safe Handling of Radioactive Sources used for Therapeutic Purposes (1988)
- Occupational standard for exposure to ultraviolet radiation, Radiation Health Series 29 (1989)
- Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields, Radiation Health Series 30 (1989)

## ICRP Publications


- *Report 27*: Recommendations of the International Commission on Radiological Protection, ICRP Publication 27, Annals of the ICRP, Pergamon, Oxford, 1977
- *Report 30*: Limits for intakes of radionuclides by workers. Pergamon, Oxford, 1979
- *Report 34*: Protection of the patient in Diagnostic Radiology, Pergamon, Oxford, 1982
- *Report 44*: Protection of the patient in Radiation Therapy, Pergamon, Oxford, 1985
- *Report 60* : Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Annals of the ICRP, Pergamon, Oxford, 1991
- *Report 61*: Annual Limits on Intake of Radionuclides by Workers Pergamon, Oxford, 1991


## ICRU Publications


- Allisy A, Jennings WA, Kellerer AM, Mueller JW and Rossi HH. *Quantities and Units in use for Radiation Protection - a draft report*. ICRU News December 1991 : 5-9