



Australian Government

**Australian Radiation Protection
and Nuclear Safety Agency**

CODE OF PRACTICE & SAFETY GUIDE

Radiation Protection in Veterinary Medicine

RADIATION PROTECTION SERIES No. 17

Radiation Protection Series

The *Radiation Protection Series* is published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to promote practices which protect human health and the environment from the possible harmful effects of radiation. ARPANSA is assisted in this task by its Radiation Health and Safety Advisory Council, which reviews the publication program for the *Series* and endorses documents for publication, and by its Radiation Health Committee, which oversees the preparation of draft documents and recommends publication.

There are four categories of publication in the *Series*:

Radiation Protection Standards set fundamental requirements for safety. They are regulatory in style and may be referenced by regulatory instruments in State, Territory or Commonwealth jurisdictions. They may contain key procedural requirements regarded as essential for best international practice in radiation protection, and fundamental quantitative requirements, such as exposure limits.

Codes of Practice are also regulatory in style and may be referenced by regulations or conditions of licence. They contain practice-specific requirements that must be satisfied to ensure an acceptable level of safety in dealings involving exposure to radiation. Requirements are expressed in 'must' statements.

Recommendations provide guidance on fundamental principles for radiation protection. They are written in an explanatory and non-regulatory style and describe the basic concepts and objectives of best international practice. Where there are related **Radiation Protection Standards** and **Codes of Practice**, they are based on the fundamental principles in the **Recommendations**.

Safety Guides provide practice-specific guidance on achieving the requirements set out in **Radiation Protection Standards** and **Codes of Practice**. They are non-regulatory in style, but may recommend good practices. Guidance is expressed in 'should' statements, indicating that the measures recommended, or equivalent alternatives, are normally necessary in order to comply with the requirements of the **Radiation Protection Standards** and **Codes of Practice**.

In many cases, for practical convenience, regulatory and guidance documents which are related to each other may be published together. A **Code of Practice** and a corresponding **Safety Guide** may be published within a single set of covers.

All publications in the *Radiation Protection Series* are informed by public comment during drafting, and Radiation Protection Standards and Codes of Practice, which may serve a regulatory function, are subject to a process of regulatory review. Further information on these consultation processes may be obtained by contacting ARPANSA.



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

CODE OF PRACTICE & SAFETY GUIDE

Radiation Protection in Veterinary Medicine

Radiation Protection Series Publication No. 17

July 2009

This publication was approved by the Radiation Health Committee on
18 May 2009, and endorsed for publication by the
Radiation Health and Safety Advisory Council on 12 June 2009

NOTICE

© Commonwealth of Australia 2009

This work is copyright. You may download, display, print and reproduce this material in unaltered form only (retaining this notice) for your personal, non-commercial use or use within your organisation. Apart from any use as permitted under the *Copyright Act 1968*, all other rights are reserved. Requests and inquiries concerning reproduction and rights should be addressed to:

Commonwealth Copyright Administration
Attorney-General's Department
Robert Garran Offices
National Circuit
Barton ACT 2600

URL: www.ag.gov.au/cca

Requests for information about the content of this publication should be addressed to the Secretariat, ARPANSA, 619 Lower Plenty Road, Yallambie, Victoria, 3085 or by e-mail to secretariat@arpansa.gov.au.

ISBN 978-0-9806797-0-0
ISSN 1445-9760

The mission of ARPANSA is to provide the scientific expertise and infrastructure necessary to support the objective of the ARPANS Act – to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation.

Published by the Acting Chief Executive Officer of ARPANSA in July 2009

Foreword

Since the early 1980s, the basis of regulation for the use of veterinary X-ray equipment and radioactive sources was the requirements of the National Health and Medical Research Council (NHMRC) *Code of practice for the safe use of ionizing radiation in veterinary radiology: Parts 1 and 2 (1982)* and *Code of practice for safe use of ionizing radiation in veterinary radiology: part 3 – radiotherapy (1984)* respectively.

Since the promulgation of these two Codes of Practice, there have been significant international advances in radiation protection. For example, the International Commission on Radiological Protection (**ICRP**) has revised its radiation protection limits and the International Atomic Energy Agency (IAEA) has published a range of radiation safety standards. These changes have been progressively reflected in other Australian Recommendations and Codes of Practice.

Australia's system of developing radiation protection guidance is now through the Radiation Health Committee, which was established under the *Australian Radiation Protection and Nuclear Safety Act 1998*. The Radiation Health Committee has agreed to develop a Radiation Protection Series of publications, which will be formed by progressively reviewing and replacing, where appropriate, existing publications in the NHMRC Radiation Health Series along with consideration of areas for new publications.

Codes of Practice reflect a regulatory style that should facilitate easier adoption into the legislation of each Australian jurisdiction. This should, in turn, result in a greater degree of uniformity of application and interpretation of the requirements of Codes of Practice across all Australian jurisdictions. A working group of the Radiation Health Committee reviewed the existing NHMRC Codes of Practice with a view to replacing them and subsequently developed this Code of Practice and Safety Guide.

The Code establishes requirements for adoption by Commonwealth, State and Territory jurisdictions that will provide a system for the safe use of veterinary radiation equipment and radioactive sources. The included Safety Guide also covers the use of radiation in veterinary medicine and informs best practice in each application of ionizing radiation. Consequently, it provides useful radiation protection information to the veterinary community.

A significant change from the NHMRC Codes includes the requirement for the Responsible Person to develop a Radiation Management Plan for use by their practice, thereby generating a safety culture in the workplace. This safety culture will, in turn, give rise to an outcome-based radiation protection program. The Code of Practice and Safety Guide also reflect the international changes mentioned above.

The Code of Practice and Safety Guide were released for a public comment period from 8 September 2005 to 7 October 2005 although late submissions were accepted beyond that date. Also released was a Regulatory Impact Statement (RIS), as required under the *COAG Principles and Guidelines for National Standard Setting and Regulatory Action by Ministerial Councils and Standard-Setting Bodies (June 2004)*.

Following the public comment period, the Radiation Health Committee reviewed the method of preparing Radiation Protection Series publications and recommended that changes be made to the draft veterinary Code of Practice to incorporate the newer style. Changes included requiring the preparation of a Radiation Management Plan and dropping the requirement for the automatic appointment of a Radiation Safety Officer among several other issues.

The public comments received were reviewed by the working group, and the final document was approved by the Radiation Health Committee on 18 May 2009, and the Radiation Health and Safety Advisory Council at their meeting of 12 June 2009 advised the CEO to adopt the Code. The Office of Best Practice Regulation cleared the final RIS on 25 February 2009.

The Code of Practice will be revised and updated from time to time to ensure that it continues to provide the highest standards of protection.



PA Burns
Acting CEO of ARPANSA

8 July 2009

Contents

Foreword	i
Code of Practice for Radiation Protection in Veterinary Medicine .	1
Safety Guide for Radiation Protection in Veterinary Medicine ...	39
Regulatory Authorities	83
ARPANSA Radiation Protection Series Publications.....	84
Bibliography	86
Glossary	87
Contributors to Drafting and Review.....	93
Index.....	94

Note: Terms that are described in the Glossary appear in **bold type** on their first occurrence in the text. The Glossary is relevant to both the Code of Practice and the Safety Guide.

(This page intentionally left blank)



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

CODE OF PRACTICE

Radiation Protection in
Veterinary Medicine

Radiation Protection Series Publication No. 17

(This page intentionally left blank)

Contents

1. Introduction	5
1.1 CITATION	5
1.2 BACKGROUND.....	5
1.3 PURPOSE.....	5
1.4 SCOPE	6
1.5 STRUCTURE.....	6
1.6 INTERPRETATION.....	6
2. Radiation Protection Principles	7
2.1 JUSTIFICATION	7
2.2 OPTIMISATION.....	7
2.3 DOSE LIMITS	7
3. Responsibilities.....	8
3.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON	8
3.2 RESPONSIBILITIES OF THE OPERATOR	15
Schedule A Radiation Management Plan.....	18
Schedule B Diagnostic Radiology	20
Schedule C Diagnostic and Therapeutic Nuclear Medicine.....	27
Schedule D Radiotherapy.....	32
Schedule E Lasers.....	37

(This page intentionally left blank)

1. Introduction

1.1 CITATION

This Code of Practice may be cited as the *Code of Practice for Radiation Protection in Veterinary Medicine (2009)*.

1.2 BACKGROUND

X-rays and radionuclides are used for the diagnosis and treatment of animals, and in research in veterinary science. In such circumstances, there is the potential for those involved to be exposed to **radiation** hazards. Hazardous **laser** radiation is also used in veterinary medicine.

This Code of Practice replaces the two Codes of Practice from the former **NHMRC** Radiation Health Series. These were RHS No. 3, *Code of Practice for the Safe Use of Ionizing Radiation in Veterinary Radiology: Parts 1 and 2 (1982)* and RHS No. 10, *Code of Practice for Safe Use of Ionizing Radiation in Veterinary Radiology: Part 3 – Radiotherapy (1984)*. In addition to updating those two Codes, this Code of Practice has been expanded to include veterinary **nuclear medicine** and the use of lasers in veterinary medicine.

1.3 PURPOSE

This Code establishes:

- (a) the radiation protection principles and regulatory requirements for the safe use of:
 - **ionizing radiation** in veterinary medicine that will, in the context of good **practice**, ensure that the risks associated with **radiation** exposure of staff and other persons are optimised and kept as low as reasonably achievable; and
 - lasers in veterinary medicine that will, in the context of good practice, ensure that the risks associated with exposure of staff and other persons are minimised;
- (b) the specific roles and responsibilities for¹:
 - the **Responsible Person**, being the person who has the overall management responsibility of the radiation source² or veterinary practice;
 - the **veterinary surgeon** who is responsible for justifying and prescribing a veterinary radiation procedure; and
 - the **operator** who exposes the animal to ionizing radiation;
- (c) a requirement for the preparation of a comprehensive Radiation Management Plan addressing the radiation protection principles; and
- (d) the management and reporting of **radiation incidents**.

¹ It is recognised that in many smaller practices, the Responsible Person, the veterinary surgeon and the operator will be the same person.

² 'Radiation source' has the same meaning as in the *National Directory for Radiation Protection, Radiation Protection Series No 6*.

1.4 SCOPE

This Code applies to the use of radiation in veterinary:

- medicine;
- teaching; and
- research,

and includes **diagnostic radiology, radiotherapy**, nuclear medicine and lasers. The Code also applies to the practice of veterinary screening investigations for equine yearling sales.

This Code details the requirements that must be followed in the use of ionizing radiation and lasers in veterinary medicine. It is supplemented by a Safety Guide that addresses good practice in radiation protection in veterinary medicine.

1.5 STRUCTURE

The Code of Practice sets out requirements to be met to achieve a satisfactory level of radiation protection in veterinary medicine. It sets out material that will be adopted by State, Territory and Commonwealth regulatory authorities as part of their regulatory controls, and in conditions of **authorisation** associated with the use of ionizing radiation within their jurisdiction.

Schedules contain additional information that form part of the Code of Practice.

1.6 INTERPRETATION

The presence of the word 'must' in a section indicates that the requirement to which it refers is mandatory.

The meanings of several terms used in this Code that have technical or legal significance, and are central to the national radiation protection framework, are defined in the Glossary.

2. Radiation Protection Principles

In this Code, the radiation protection principles of justification, optimisation and **dose** limitation are applied to radiation protection in veterinary medicine.

2.1 JUSTIFICATION

The justification principle is common to all practices involving exposure to ionizing radiation. This principle can be stated as follows:

*No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation **detriment** it causes³.*

2.1.1 Before a veterinary procedure involving exposure to ionizing radiation is approved or commenced, the procedure must be justified⁴.

2.2 OPTIMISATION

2.2.1 Veterinary equipment and methods must be selected to ensure that the radiation doses received by occupationally exposed persons and members of the public are kept as low as reasonably achievable, economic and social factors being taken into account.

2.3 DOSE LIMITS

2.3.1 All veterinary applications of ionizing radiation must be managed so that radiation doses to occupationally exposed persons and members of the public do not exceed the dose limits specified in **RPS1**.

³ ICRP 60 (1991), paragraph 112.

⁴ Justification may take into account a generic justification applicable to a well established procedure as defined through the relevant professional bodies.

3. Responsibilities

3.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON

Radiation Management Plan

- 3.1.1 The Responsible Person must ensure that:
- (a) a Radiation Management Plan that incorporates the components listed in Part A1 of Schedule A of this Code is developed, documented, resourced, implemented and regularly reviewed;
 - (b) the Radiation Management Plan prepared under 3.1.1(a) describes the management and reporting arrangements that enable the veterinary surgeon and operator to discharge their obligations under this Code; and
 - (c) all persons affected by the Radiation Management Plan follow and comply with the Radiation Management Plan.
- 3.1.2 Where a practice generates radioactive waste, the Responsible Person must ensure that the Radiation Management Plan includes a section on Radioactive Waste Management that incorporates the components listed in Part A2.1 of Schedule A of this Code.

Approval of a veterinary radiation procedure

- 3.1.3 The Responsible Person must ensure that a veterinary surgeon approves a procedure involving the exposure of an animal to ionizing radiation and, in doing so, that veterinary surgeon:
- (a) complies with the relevant provisions of the Radiation Management Plan;
 - (b) justifies the radiation exposures in accordance with 3.1.4; and
 - (c) optimises the radiation exposures in accordance with 3.1.6.

Justification of a veterinary radiation procedure

- 3.1.4 The Responsible Person must ensure that in determining the net benefit from a veterinary radiation procedure, the veterinary surgeon takes into account:
- (a) the need to carry out the procedure;
 - (b) the potential detriment to:
 - (i) the operator;
 - (ii) assistants; and
 - (iii) the owner or carer of the animal; and
 - (c) the efficacy, benefits and risk of available alternate techniques having the same objectives with less or no exposure to ionizing radiation.

Optimisation and limitation of exposure

- 3.1.5 The Responsible Person must ensure that radiation doses to occupationally exposed persons and members of the public:
- (a) do not exceed the dose limits specified in RPS1; and
 - (b) are kept as low as reasonably achievable, economic and social factors being taken into account.
- 3.1.6 The Responsible Person must ensure that the veterinary surgeon who approves a veterinary radiation procedure optimises the radiation dose arising from that procedure.
- 3.1.7 The Responsible Person must ensure that the veterinary facility is designed, constructed, shielded, used, and maintained so that the dose:
- (a) constraints acceptable to the **relevant regulatory authority** are applied; and
 - (b) limits to occupationally exposed persons and members of the public are not exceeded.

Authorisation of operators

- 3.1.8 The Responsible Person must ensure that only persons who are appropriately authorised by the relevant regulatory authority:
- (a) operate radiation-producing equipment; or
 - (b) use or handle:
 - (i) **radioactive sources**; or
 - (ii) radioactive waste.

Radiation monitoring

- 3.1.9 The Responsible Person must ensure that:
- (a) a **personal radiation monitoring device** supplied by a Personal Radiation Monitoring Service, approved in accordance with the criteria specified in the *National Directory for Radiation Protection*, is provided to each occupationally exposed person who is likely to be exposed to ionizing radiation in excess of 1 mSv in any one year;
 - (b) for each occupationally exposed person who is likely to be exposed to internal **radioactive material** resulting in an **effective dose** in excess of 1 mSv in any one year, internal radiation dose assessments and biological monitoring are carried out as detailed in the *National Directory for Radiation Protection*;
 - (c) a record is kept of the radiation doses received by each occupationally exposed person in accordance with the requirements of RPS1; and

- (d) work practices are investigated and reviewed if an occupationally exposed person receives effective doses in excess of the **dose constraints** acceptable to the relevant regulatory authority.

Pregnant workers

- 3.1.10 When an occupationally exposed female declares that she is pregnant, the Responsible Person must, if necessary, adapt the working conditions of the pregnant female so as to ensure that the embryo or fetus is afforded the same level of protection as that of a member of the public as specified in RPS1.

Accountability for radiation sources

- 3.1.11 The Responsible Person must, at all times, be able to account for all:
- (a) **radiation-producing equipment** within the Responsible Person's control; and
 - (b) radioactive sources or radiopharmaceuticals within the Responsible Person's control.
- 3.1.12 The Responsible Person must:
- (a) ensure that a Radiation Source Register is maintained and updated with information relating to:
 - (i) the acquisition, relocation, replacement or disposal of all radiation-producing equipment or **sealed radioactive sources**; and
 - (ii) the maximum **activity** of each unsealed radionuclide that the veterinary facility has:
 - (iii) been authorised to possess; and
 - (iv) used;
 - (b) advise the relevant regulatory authority of the receipt or disposal of any:
 - (i) radiation-producing equipment; or
 - (ii) sealed radioactive source (unless the relevant regulatory authority has issued an authorisation that includes a generic approval for receipt or disposal).

Radiation incident

- 3.1.13 In the event of a radiation incident, the Responsible Person must:
- (a) ensure that the radiation incident is investigated;
 - (b) submit a written report of a **reportable radiation incident**, including the preventative action to avoid a recurrence, to the relevant regulatory authority within 7 days; and
 - (c) in the case of a radiation source that is, or may be, lost or stolen, immediately report the event to the relevant regulatory authority.

3.1.14 The Responsible Person must ensure that:

- (a) an internal report on each radiation incident is written and kept in the institution's radiation incident report register; and
- (b) measures are implemented so that the possibility of the recurrence of the radiation incident investigated in 3.1.13(a) is minimised.

Training

3.1.15 The Responsible Person must ensure that each person who may be occupationally exposed to ionizing radiation has training⁵ or instruction that relates to:

- (a) the type of work being undertaken;
- (b) the radiation source, and related ancillary equipment, that the individual may be required to use;
- (c) any potential radiation hazards associated with the practice;
- (d) the means of protection and minimisation of unwanted radiation exposure; and
- (e) requirements for complying with the Radiation Management Plan.

Radiation shielding

3.1.16 The Responsible Person must ensure that radiation shielding:

- (a) is employed, as appropriate, in or around an area in which a radiation source is to be used
- (b) meets the requirements of the Radiation Management Plan; and
- (c) is documented:
 - (i) as part of the installation procedure of the fixed radiation-producing equipment; and
 - (ii) where shielding modifications are made subsequent to installation.

Warning notices

3.1.17 The Responsible Person must ensure that:

- (a) each access point into a radiation area has a visible warning sign or device to indicate that the room contains an ionizing radiation hazard;
- (b) an radiation warning sign displaying the illuminated words 'IONIZING RADIATION – DO NOT ENTER' (or equivalent) is positioned directly adjacent to any entry point of any room that houses:

⁵ Specific competency requirements are established in the *National Directory for Radiation Protection*.

- (i) fixed radiation-producing equipment used for external beam radiotherapy, fixed fluoroscopy or computed tomography; or
- (ii) remote afterloading brachytherapy equipment; and
- (c) the illuminated sign required in (b) is illuminated immediately:
 - (i) as the radiation-producing equipment is placed in the preparation mode prior to exposure and continues to illuminate during the exposure; or
 - (ii) as the radioactive source is driven out of its shielded housing and continues to illuminate until the source has been returned to the shielded position.

Expert advice

3.1.18 The Responsible Person must ensure that the advice of a **qualified expert** is available on matters relating to radiation protection in veterinary medicine.

Radiation Procedures

3.1.19 Subject to a specific authorisation from the relevant regulatory authority for each modality, the Responsible Person must ensure that:

- (a) diagnostic radiography is only carried out in accordance with the relevant sections of Schedule B;
- (b) dental equipment used for veterinary procedures meets the requirements of section B8 of Schedule B;
- (c) radiography using capacitor discharge X-ray equipment is only carried out using equipment that meets the requirements of section B9 of Schedule B;
- (d) fluoroscopy is only carried in accordance with sections B1, B6 and B7 of Schedule B;
- (e) nuclear medicine is only carried out in accordance with the relevant sections of Schedule C;
- (f) radiotherapy is only carried out in accordance with the relevant sections of Schedule D; and
- (g) laser procedures are only carried out in accordance with Schedule E.

Equipment calibration – radiotherapy

3.1.20 The Responsible Person must ensure that:

- (a) all radiation-producing therapy equipment, equipment containing radioactive sources and remote afterloading brachytherapy equipment are:
 - (i) appropriately calibrated by a qualified expert at the time of installation; and
 - (ii) checked and recalibrated by a qualified expert at intervals specified in national or international protocols;

- (b) the use of radiation-producing therapy equipment and remote afterloading brachytherapy equipment is restricted to those techniques for which the equipment has been calibrated; and
- (c) the calibration of reference and radiation-measuring equipment is traceable to relevant national standards.

Radiotherapy treatment planning

3.1.21 The Responsible Person must ensure that:

- (a) radiotherapy treatment planning procedures are followed;
- (b) all radiotherapy treatment planning equipment is tested; and
- (c) a qualified expert verifies the basic data for each available radiotherapy treatment planning computer program, where fitted:
 - (i) on initial acceptance; or
 - (ii) after any change or upgrade.

Equipment repair, maintenance or modification

3.1.22 The Responsible Person must ensure that following any repair, maintenance or modification on a radiation source that could affect radiation safety:

- (a) the operation of the equipment is re-assessed so that the radiation safety of staff and the public is maintained; and
- (b) a radiation survey is carried out on fixed radiation-producing equipment or radioactive source by a qualified expert.

3.1.23 The Responsible Person must ensure that, following any repair, maintenance or modification on radiation-producing therapy equipment, including radiation source changes, which could alter the dose output, a qualified expert calibrates the equipment before it is returned to use.

3.1.24 The Responsible Person must ensure that a written record is kept detailing the work performed on a radiation source following any repair, maintenance or modification on that source.

3.1.25 Where the Responsible Person is informed that a fault that could compromise the safety of the operator, staff or the public has been identified on a radiation source, and where the fault could be one which might be present in other similar equipment, the Responsible Person must:

- (a) report the details of the fault to the relevant regulatory authority; and
- (b) ensure that a record is maintained of:
 - (i) such faults; and
 - (ii) the corrective maintenance performed.

Death of an animal

- 3.1.26 The Responsible Person must have systems in place to ensure that in the event of the death of an animal with radioactive material above the relevant activity exemption level in situ:
- (a) exposure to radiation of any person handling the corpse is minimised;
 - (b) each temporarily implanted sealed source or radioactive applicator is removed;
 - (c) consideration is given as to whether a permanent radioactive implant or tissue containing unsealed radioactive material is to be excised;
 - (d) the level of activity of a permanent implant or unsealed radioactive material remaining in the corpse is calculated and documented; and
 - (e) where a permanent implant or unsealed radioactive material remains in the body, written instructions regarding handling and safety are provided to each person who handles the corpse.

Provision of advice to owners or handlers

- 3.1.27 Where an animal is discharged while undergoing treatment with an implanted radioactive source or with a radiopharmaceutical, the Responsible Person must ensure that the veterinary surgeon who approves the procedure provides the animal's owner or **handler** with written information and instructions, before the animal leaves the place where the radiation procedure took place, which address:
- (a) the risks associated with ionizing radiation exposure to handlers and other persons;
 - (b) how to restrict exposures to persons that could result from proximity to the animal, if relevant;
 - (c) storage or disposal of any dislodged radioactive sources, if relevant;
 - (d) prevention of **contamination**, if relevant; and
 - (e) procedures in the event of contamination.

High Dose Rate (HDR) brachytherapy

- 3.1.28 The Responsible Person must ensure that a veterinary surgeon is available:
- (a) for all HDR brachytherapy procedures; and
 - (b) while a radioactive source is within an animal, where assistance could be required to remove a source-containing applicator from the animal in the event of an emergency.

3.2 RESPONSIBILITIES OF THE OPERATOR

Authorisation to perform veterinary radiation procedures

3.2.1 Only a person who is appropriately authorised by the relevant regulatory authority may perform ionizing radiation procedures on an animal for:

- (a) diagnostic or **interventional radiology**;
- (b) veterinary screening investigations for equine yearling sales;
- (c) nuclear medicine; or
- (d) radiotherapy.

Delivery of a radiation procedure

3.2.2 The operator must:

- (a) not carry out an ionizing radiation procedure unless the procedure has been formally requested by a veterinary surgeon;
- (b) follow the established protocol for the procedure;
- (c) ensure that the radiation exposure of persons is minimised; and
- (d) in the case of radiotherapy, ensure that:
 - (i) the radiation treatment plan has been approved by the veterinary surgeon;
 - (ii) there is a continuous oversight of the operating parameters of radiation-producing equipment during the radiation dose delivery; and
 - (iii) the exposure from radiation-producing equipment is immediately terminated if there is any concern that the equipment will not deliver the correct radiation dose.

General requirements for an operator

3.2.3 The operator must comply with the relevant provisions of the Radiation Management Plan.

3.2.4 The operator must wear:

- (a) all personal protective equipment provided by the Responsible Person where applicable to the procedure; and
- (b) a personal radiation monitoring device where provided by the Responsible Person.

Identification of the animal

3.2.5 Immediately before conducting a radiation procedure on an animal, the operator must:

- (a) take reasonable steps to ensure that the animal is correctly identified; and
- (b) ensure that the specified or prescribed procedure is to be performed on the animal.

Control of exposure to persons

- 3.2.6 The operator must ensure that no person is in the imaging, administration or treatment area during a radiation exposure or the administration of a radioactive source to an animal unless that person is required to be in attendance.
- 3.2.7 The operator must ensure that all assistants:
- (a) remain behind protective screens; or
 - (b) where there is no protective screen:
 - (i) wear protective clothing; and
 - (ii) position themselves as far as practicable from the X-ray tube assembly, the animal and the path of the primary X-ray beam.
- 3.2.8 The operator must ensure that, for radiography procedures:
- (a) the primary X-ray beam is restricted to the area to be examined by means of the collimator or light beam diaphragm;
 - (b) cassette holders are used whenever a cassette cannot be supported on a table, on the ground or on another support;
 - (c) any person supporting a cassette holder remains as far as practicable, preferably at least 1 metre, from the edge of the primary beam; and
 - (d) no part of any person, even if shielded by protective clothing, is exposed to the primary X-ray beam.
- 3.2.9 The operator must ensure that persons under the age of 18 years do not hold animals during radiography and a notice to this effect is displayed prominently in the X-ray area.
- 3.2.10 The operator of computed tomography equipment, equipment that delivers external beam radiotherapy, intra-operative radiotherapy equipment or HDR brachytherapy equipment must:
- (a) ensure that no person is in the room during the time that the equipment is emitting radiation or the radioactive source is exposed unless the circumstances are specified in the Radiation Management Plan;
 - (b) ensure that visual surveillance of the treatment room is maintained for the time that:
 - (i) the radiation-producing equipment is delivering the exposure; or
 - (ii) the radioactive source is exposed; and
 - (c) immediately terminate the exposure if any person might be accidentally exposed.

Equipment

3.2.11 The operator of radiation-producing equipment or equipment containing radioactive source(s) must ensure that no safety interlock devices are bypassed at any time during routine use of the equipment.

Equipment fault or error

3.2.12 The operator of veterinary radiation-producing equipment, equipment containing radioactive sources or other associated apparatus, who experiences any fault or error of equipment or system, or unusual operating behaviour must:

- (a) immediately cease using the equipment or apparatus until the fault, error or unusual operating behaviour is rectified;
- (b) record the details of the fault, error or unusual operating behaviour; and
- (c) where the fault could compromise safety, diagnosis or treatment, report it to:
 - (i) the Responsible Person; and
 - (ii) the veterinary surgeon.

Radiation incidents

3.2.13 The operator must report any radiation incident within 24 hours to:

- (a) the Responsible Person in accordance with the procedures set out in the Radiation Management Plan; and
- (b) the veterinary surgeon.

Schedule A

Radiation Management Plan

A1 PREPARATION OF THE RADIATION MANAGEMENT PLAN

A1.1 The Radiation Management Plan⁶ must address the following:

- (a) a description of each type of radiation hazard at the veterinary facility or premises;
- (b) work practices and protocols for all procedures involving exposure to ionizing radiation, including those:
 - (i) to ensure that the specified or prescribed radiation procedure is performed on the correct animal;
 - (ii) for the proper planning and delivery of radiotherapy doses; and
 - (iii) for preparation and dispensing of radiopharmaceuticals;
- (c) methods for optimising the shielding, where appropriate, so that external radiation exposure rates are kept as low as reasonably achievable, economic and social factors being taken into account;
- (d) the action to be taken if the radiation doses to occupationally exposed persons or members of the public are found to exceed the dose constraints;
- (e) observation⁷ of the animal by the operator throughout procedures where the dosimetry or image quality could be affected by movement of the animal;
- (f) arrangements for appropriate isolation within the veterinary facility of animals undergoing treatment with sealed or **unsealed radioactive sources**;
- (g) the training, qualifications and supervision of the staff of the veterinary facility and their roles and responsibilities;
- (h) the licensing requirements of the radiation regulatory authority;
- (i) personal radiation monitoring requirements for persons involved in the use of radiation;
- (j) personal protective equipment to be worn by persons involved in the use of radiation;
- (k) safety devices and ancillary equipment, including animal restraints, to be used by persons involved in the use of radiation;
- (l) actions necessary to manage a radiation incident, including reporting (both internal and to the radiation regulatory authority) and investigation of the radiation incident;
- (m) emergency procedures in response to radiation incidents;
- (n) procedures for the reporting of any fault with a radiation source that could compromise safety, diagnosis or treatment;
- (o) arrangements for the storage of radioactive material;

⁶ The Radiation Management Plan may make reference to, and utilise, other documented safety procedures and work practices.

⁷ Observation may be by indirect means such as video surveillance.

- (p) arrangements for the transport of radioactive material;
- (q) arrangements for radioactive waste management, if relevant;
- (r) mechanisms for implementation of the Radiation Management Plan;
- (s) mechanisms for, and frequency of, review of the Radiation Management Plan;
- (t) arrangements for obtaining expert advice in radiation protection;
- (u) security and access control arrangements for radiation sources; and
- (v) any other requirement that may have a bearing on radiation safety.

A1.2 Where other documented safety procedures and work practices that exist within the organisation are referred to or used:

- (a) the Responsible Person must have authority over the safety procedures and work practices referred to; and
- (b) the safety procedures and work practices referred to must not be modified without consideration of the effect on the Radiation Management Plan.

A2 REQUIREMENTS FOR RADIOACTIVE WASTE MANAGEMENT

A2.1 A Radiation Management Plan that includes Radioactive Waste Management must address the following:

- (a) mixed waste hazards⁸;
- (b) the necessary equipment and instructions for the safe handling and disposal of all radioactive waste in accordance with any authorisation issued by the relevant regulatory authority;
- (c) procedures to ensure that all persons involved in the handling of radioactive waste receive, understand and comply with the radioactive waste management requirements;
- (d) the storage of all radioactive waste in adequately shielded containers or in a secure shielded room, as appropriate to the nature of the waste, so as to ensure no member of the public receives an effective dose greater than the relevant limit specified in RPS1;
- (e) procedures to ensure that all radioactive waste leaving the facility, either as gaseous or liquid effluent discharged to the environment or sewerage system, does so within the relevant requirements specified in the *National Directory of Radiation Protection*; and
- (f) notification to the relevant regulatory authority of any radiation incident which has, or may have, resulted, or may result in:
 - (i) a discharge of effluent in excess of the relevant discharge limit; or
 - (ii) spillage of radioactive waste during transport.

⁸ The radioactive waste may also be flammable, toxic, infectious or putrescible material.

Schedule B

Diagnostic Radiology

B1 GENERAL REQUIREMENTS

- B1.1 Diagnostic radiology must only be undertaken if:
- (a) there is a clear indication for the procedure; and
 - (b) it can be done without undue radiation hazard.
- B1.2 Only people who are essential to a procedure are permitted to be present during radiological examinations.
- B1.3 Each person present during a radiological examination must be:
- (a) properly instructed to enable them to understand their part in the proposed procedure; and
 - (b) where practicable, positioned behind a protective screen.
- B1.4 Each person who is unable to position themselves behind a protective screen must:
- (a) wear a protective apron; and
 - (b) remain as far as practicable from:
 - (i) the primary X-ray beam,
 - (ii) the animal, and
 - (iii) the X-ray tube assembly.
- B1.5 Adequate facilities and devices must be available to ensure:
- (a) physical control over the animal; and
 - (b) protection of the operator.
- B1.6 Radiography must only be carried out using an appropriate X-ray machine that satisfies the relevant requirements of this Schedule.
- B1.7 Radiography may be considered in two categories:
- (a) radiography within a defined X-ray room or area (see section B2); or
 - (b) radiography outside a defined X-ray room or area when a mobile or portable X-ray machine is taken to the animal (see section B3).

B2 RADIOGRAPHY IN DEFINED X-RAY ROOMS OR AREAS

- B2.1 A defined X-ray room or area must have sufficient shielding to ensure that no person can receive a radiation dose in excess of the relevant radiation protection limits specified in RPS1.

B3 RADIOGRAPHY OUTSIDE DEFINED X-RAY ROOMS OR AREAS

- B3.1 An X-ray examination must not be carried out outside a defined X-ray room or area unless it is not practicable to bring the animal to that room or area.

B4 DIAGNOSTIC X-RAY EQUIPMENT – GENERAL

- B4.1 An X-ray machine must have sufficient capacity to produce radiographs of acceptable diagnostic quality for the intended procedure.
- B4.2 Diagnostic X-ray equipment used for veterinary medicine must meet the following requirements:
- (a) **Warning signs:** the X-ray control panel must bear a permanent and conspicuous sign:
 - (i) prohibiting unauthorised use, and
 - (ii) warning that hazardous X-radiation is emitted when the equipment is in operation;
 - (b) **Markings:** all controls, meters, lights and other indicators relevant to the operation of the equipment must be:
 - (i) readily discernible; and
 - (ii) clearly labelled as to function;
 - (c) **Irradiation Indicator:** the control panel must have a readily discernible, separate indicator that indicates when X-rays are being produced;
 - (d) **Mechanical Stability:** the X-ray unit must be arranged so that:
 - (i) the X-ray tube is:
 - A. securely fixed; and
 - B. correctly aligned within the X-ray tube housing;
 - (ii) the X-ray **source assembly** maintains its required position without drift, oscillation or vibration during operation;
 - (e) **Irradiation Control:** each X-ray unit must be fitted with an irradiation switch, timer, or other device that:
 - (i) initiates and terminates X-ray production;
 - (ii) requires continuous pressure by the operator to produce X-rays;
 - (iii) in the case of a foot switch, is constructed so that X-rays cannot be produced by accidental activation of the switch;
 - (iv) is an electronic type;
 - (f) **Indication of Loading Factors:** for X-ray equipment having
 - (i) adjustable loading factors, the control panel must incorporate indicators that show the loading factors; and
 - (ii) non-adjustable loading factors, permanent marks or labels must be used to indicate these parameters;
 - (g) **Irradiation Reproducibility:** for any selected combination of X-ray tube voltage, current and time, the **coefficient of variation** of any 5 consecutive irradiations taken at the same distance within a period of 10 minutes must not exceed 0.05;
 - (h) **X-ray Tube Shielding:** the X-ray tube must be enclosed in a shielded housing so that the leakage radiation from the X-ray tube housing does not exceed 1 mGy in 1 hour at 1 metre from the focal spot at the maximum X-ray tube voltage at which the equipment can be operated;

- (i) **Half-Value Layer:** for a given kilovoltage peak (kVp)⁹ specified in column 1 of Table 1, the measured value of half-value layer of the useful beam must not be less than the level specified in column 2 of Table 1:

TABLE 1: HALF VALUE LAYERS¹⁰

Column 1	Column 2
Operating Potential kilovoltage peak (kVp)	Half Value Layer (mm Al. eq.)
50	1.5
60	1.8
70	2.1
80	2.3
90	2.5
100	2.7
110	3.0
120	3.2
130	3.5
140	3.8
150	4.1

B5 DIAGNOSTIC X-RAY EQUIPMENT – RADIOGRAPHY

- B5.1 In addition to the general requirements for veterinary radiology equipment specified in Section B4, equipment used for veterinary radiography must have:
- (a) an irradiation control device that automatically terminates the irradiation after reaching a preset:
 - (i) time;
 - (ii) product of tube current and time; or
 - (iii) air **kerma** value;
 - (b) a light beam collimator (LBC) that:
 - (i) enables adjustment of the size of the X-ray field;
 - (ii) incorporates a means to indicate the size of the X-ray field at the image reception area;
 - (iii) ensures that the respective edges of the X-ray field along either the length or the width of the visually defined field do not exceed 1% of the distance from the source to the centre of the visually defined field when the surface on which it appears is perpendicular to the central axis of the useful X-ray beam;
 - (iv) ensures that the visually defined field (light field) contains cross-wires or other acceptable mode of indicating the centre of the X-ray beam (dark cross-wires on an illuminated field are preferred to illuminated cross wires on a dark field.);

⁹ For a capacitor discharge X-ray unit, kVp means the kV value selected.

¹⁰ Reference: Australian Standard AS3200.1.3

- (v) ensures that the centre of the X-ray beam and indicated centre of the light beam correspond to an accuracy of within 1% of the distance from the source to the point on the illuminated surface at which it appears;
- (vi) ensures that the brightness of the light field is sufficiently great that the light field is clearly visible in ambient illumination; and
- (vii) clearly shows the outer edges of the light field with a high edge-field contrast ratio.

B6 FLUOROSCOPY PROCEDURES

Fluoroscopy is potentially more hazardous than radiography because the product of exposure time and X-ray tube current is usually greater in fluoroscopy and because the operators stand nearer the primary beam and the animal. The detail that can be achieved in fluoroscopy is inferior to that which can be seen radiographically, and involves additional risks.

- B6.1 Fluoroscopy must not be used as:
- (a) the primary diagnostic tool; or
 - (b) an alternative to radiography.
- B6.2 Fluoroscopy is only indicated:
- (a) in circumstances in which it is essential to study movement; or
 - (b) for complex surgical techniques.
- B6.3 In these cases, it is important to consider the use of a fluoroscopy unit with image storage facilities to minimise radiation dose levels further.
- B6.4 Fluoroscopy must only be only carried out if suitable equipment is available.
- B6.5 Each operator of fluoroscopic imaging equipment must have:
- (a) adequate knowledge and training to use the equipment;
 - (b) adequate knowledge, training and experience in the technique; and
 - (c) appropriate authorisation from the relevant regulatory authority to use fluoroscopy equipment.

B7 DIAGNOSTIC X-RAY EQUIPMENT – FLUOROSCOPY

- B7.1 In addition to the general requirements for veterinary radiology equipment specified in Section B4, equipment used for fluoroscopy radiography must have:
- (a) a properly installed and maintained X-ray image intensification system;
 - (b) a remote television display for group viewing and teaching purposes;
 - (c) air kerma rates that:
 - (i) during fluoroscopy do not exceed the values given in Table 2 measured under the conditions given in Table 3; and
 - (ii) at the input surface of an image intensifier do not exceed the relevant value given in Table 4;

TABLE 2: AIR KERMA RATES DURING FLUOROSCOPY

Manual	Automatic	High level (boost) ¹¹
50 mGy/min	100 mGy/min	150 mGy/min

TABLE 3: TEST CONDITIONS

Conditions	Measurement distance
UNDER-TABLE X-RAY TUBE When an animal support is permanently between the X-ray tube assembly and the position of the animal.	10 mm from the animal support on the animal side of the support.
OVER-TABLE X-RAY TUBE When an animal support is permanently between the position of the animal and the X-ray image receptor.	300 mm above the animal support on the X-ray tube side of the support.
FIXED ARM SYSTEMS Where the X-ray tube and the image receptor are mechanically linked and where an animal support may or may not be permanently in the radiation beam.	300 mm from the image receptor plane but not less than 400 mm from the focal spot.
OTHER FLUOROSCOPY SYSTEMS Where no animal support is permanently in the radiation beam.	400 mm from the focal spot or the minimum distance, whichever is greater.

TABLE 4: AIR KERMA RATES AT THE FIELD INPUT SURFACE

Field size (mm)	Air kerma rate ($\mu\text{Gy}/\text{min}$)
110 to < 140	120
140 to < 230	80
≥ 230	60

MEASUREMENT CONDITIONS
The measurement conditions are to be such that sufficient copper filtration is added to the X-ray beam to obtain, on automatic brightness/dose rate systems, an X-ray tube voltage between 70 kVp and 80 kVp.

For acceptable manual systems, these air kerma rates are not exceeded for the normal clinical settings when used with average animals.

The measurements are to be obtained without the grid or alternatively, by applying a traceable grid correction factor for the energy of the radiation beam being used.

B8 VETERINARY DENTAL X-RAY EQUIPMENT

- B8.1 Where dental X-ray equipment is used for veterinary procedures, it must:
- (a) only be operable at potential differences of up to 90 kVp;
 - (b) be fitted with an open ended beam applicator that:
 - (i) limits the maximum dimension of the X-ray field at the open end of the beam applicator to no greater than 60 mm;
 - (ii) ensures that the outline of the open end of the beam applicator:

¹¹ Equipment is acceptable only if access to the high level (boost) mode is restricted to being via the automatic mode of operation.

- A. coincides with the size and position of the X-ray field, and
 - B. at no point, is more than 3 mm outside the corresponding point of the X-ray field;
- (c) have total filtration so that the measured value of half-value layer of the useful beam is not less than the level specified in column 2 of Table 1 for a given kilovoltage peak (kVp) specified in column 1 of Table 1;
 - (d) have sufficient shielding so that the kerma in air from leakage radiation from the tube assembly, including cones, diaphragms and collimator, does not exceed 0.25 mGy in 1 hour at a distance of 1 metre from the focal spot;
 - (e) be designed to permit the operator to preset exposure factor(s) without the need for energising the X-ray tube to check on the operation of the equipment;
 - (f) where the X-ray equipment operates at fixed potential differences and currents, have the exposure factors indicated on labels attached to the equipment;
 - (g) where the X-ray equipment operates at variable potential differences or currents, have the selected tube potential difference, tube current and exposure time or current time product indicated by:
 - (i) analogue meters;
 - (ii) digital displays or scales; or
 - (iii) calibrated permanent markings;
 - (h) where a milliammeter is provided, have its full scale reading at least 110 percent of the maximum nominal tube current of the equipment;
 - (i) have a means of indicating:
 - (i) when the main switch is in the 'ON' position; and
 - (ii) the control panel is energised;
 - (j) have a clearly visible light to indicate when the X-ray tube is energised;
 - (k) have a signal audible to the operator, other than the sound produced fortuitously by switching devices or contactors during the exposure, to indicate:
 - (i) the duration of the exposure; or
 - (ii) termination of the exposure;
 - (l) have the signals specified above located at:
 - (i) the control panel; or
 - (ii) for remotely controlled equipment, the position of the operator;
 - (m) have the exposure switch arranged so that the X-ray equipment can be operated from a distance of at least 2 metres from the X-ray tube and the animal;
 - (n) have all exposure switches:
 - (i) of the dead-man type, so that continuous pressure is necessary to maintain the X-ray exposure, and
 - (ii) such that it is not possible to make repeat exposures without releasing that switch;

- (o) be equipped with an electronic timer that:
 - (i) terminates an exposure at a preset:
 - A. time interval; or
 - B. product of current and time;
 - (ii) where an icon is used to indicate the exposure, has the exposure time clearly displayed on the timer or the timer handpiece;
 - (iii) ensures that it is not possible to initiate an exposure if the timer is set to zero;
 - (iv) allows the timer setting to be altered to a higher or lower value after the initial adjustment without initiating an exposure;
 - (v) where an image receptor sensitivity control is provided, clearly indicate¹² the:
 - A. exposure setting for the image receptor (e.g. for 'D', 'E' or 'F' speed film); or
 - B. setting for electronic (digital) radiography,
- (p) where the exposure is initiated by an infra-red or wireless remote control handpiece, have:
 - (i) the X-ray generator and handpiece encoded so that no other remote control handpiece can initiate exposures,
 - (ii) provision for storage of the remote control handpiece at the control panel; and
 - (iii) the remote control handpiece is permanently labelled with a warning identifying its purposes; and
- (q) ensure that the X-ray tube head remains stationary when placed in position for radiography.

B9 CAPACITOR DISCHARGE X-RAY EQUIPMENT¹³

B9.1 Each capacitor discharge X-ray unit must

- (a) meet the requirements of Sections B4 and B5 above; and
- (b) be fitted with a device¹⁴ that:
 - (i) when the exposure switch is not activated, ensures that the air kerma rate from any accessible surface of the X-ray tube housing, including the associated diaphragm or light beam collimator, does not exceed $20 \mu\text{Gy}\cdot\text{h}^{-1}$ at 0.05 m even when the collimator is fully open, and
 - (ii) enables the capacitor(s) to be discharged without exceeding these levels.

¹² For acceptable equipment provided with an image receptor sensitivity control, the indicator bears appropriate labelling or has an appropriate display and is positioned at the user's location. The last value selected is the default. **Suppliers** or installers of dental X-ray equipment fitted with such a control should ensure that it is initially set to match the image receptor speed used by the purchaser. Incorrect image receptor speed settings may result in the animal (and users) being exposed to significantly higher radiation doses than necessary. Electronic (digital) imaging systems generally require significantly lower exposures than those required for conventional films.

¹³ These units are often known as 'CD mobiles' or 'CD X-ray units'.

¹⁴ Such a device is commonly known as a 'blackout' or 'dark' shutter. If a capacitor discharge X-ray unit is not fitted with a blackout shutter, the operator or staff may be unknowingly exposed to the primary X-ray beam.

Schedule C

Diagnostic and Therapeutic Nuclear Medicine

C1 PROCEDURES AND FACILITIES

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

- C1.1 Diagnostic or therapeutic nuclear medicine veterinary procedures must only be performed:
- (a) in an area that is specially designed for the purpose; and
 - (b) subject to a specific authorisation from the relevant regulatory authority.
- C1.2 Diagnostic veterinary nuclear medicine must only be undertaken by personnel who:
- (a) are specifically trained in:
 - (i) radiation physics;
 - (ii) radiation biology; and
 - (iii) radiation hazards and protection,
 - (b) have practical experience in:
 - (i) nuclear medicine instrumentation;
 - (ii) imaging procedures;
 - (iii) quality control of the radiopharmaceuticals;
 - (iv) the handling of unsealed radioactive materials; and
 - (v) hot laboratory procedures & clinical practice, and
 - (c) are appropriately authorised by the relevant regulatory authority.
- C1.3 Therapeutic veterinary nuclear medicine must only be undertaken by personnel who:
- (a) meet the requirements specified in clause C1.2 for diagnostic nuclear medicine; and
 - (b) have additional training in:
 - (i) the biological pathways and distribution of radioactive materials;
 - (ii) radiation dosimetry;
 - (iii) experience in spillage mediation procedures; and
 - (iv) handling radioactive waste at levels encountered in therapy.
- C1.4 Detailed written procedures must be developed for:
- (a) decontamination; and
 - (b) the disposal of radioactive waste.

- C1.5 Dedicated facilities must be used for:
- (a) storage, safe handling, manipulation and dispensing of unsealed radioactive sources;
 - (b) administration of unsealed radioactive materials to animals;
 - (c) subsequent housing of the animals;
 - (d) measurements of the radioactive materials in the animals and any subsequent investigations; or
 - (e) housing the animals before discharge once the studies are completed.

C1.6 Appropriate radiation warning signs and instructions must be displayed on the kennel, box, stall or other enclosure in which the animal will be housed.

C1.7 Written protocols for each type of nuclear medicine procedure must be developed before the procedures are implemented.

C1.8 Suitable arrangements must be made for the discharge or disposal of animals.

C1.9 A record of the receipt, use and disposal of all radioactive materials must be maintained.

C2 SPECIFIC NUCLEAR MEDICINE PROCEDURES

C2.1 *Technetium-99m*: The following requirements must be implemented when using technetium-99m for nuclear medicine procedures:

- (a) an isolated, shielded and secure accommodation must be used for:
 - (i) administering the radioactive material; and
 - (ii) hospitalising the animal after the administration¹⁵.
- (b) all personnel involved must be made aware that they are handling a radioactive animal;
- (c) the procedures and precautions must be:
 - (i) carefully planned; and
 - (ii) explained to all personnel involved with handling a radioactive animal;
- (d) suitable animal restraints must be provided to minimise handling of the radioactive animal during imaging or other procedures;
- (e) persons under the age of 18 years and pregnant women must not hold animals during nuclear medicine procedures and a notice advising of this requirement should be displayed prominently in the area;
- (f) a separate shielded and secure location must be used for the imaging procedure;
- (g) in order that they can be hosed down to remove any radioactive contamination, the walls and fixtures in rooms used for nuclear medicine procedures must be:
 - (i) waterproof and 'non-slip'; or
 - (ii) painted with waterproof paint,

¹⁵ For the normal doses of technetium-99m used in bone imaging, the animal may be discharged the day after administration of the dose.

- (h) the floors must be sealed;
- (i) the flooring material must:
 - (i) be readily cleanable;
 - (ii) cover the whole imaging area; and
 - (iii) be sealed or covered up at the edges,
- (j) drainage must be provided to the normal establishment waste;
- (k) procedures to minimise the contamination from urination must be considered¹⁶;
- (l) decontamination equipment must be available for easy and rapid decontamination of the area;
- (m) bedding material must be absorbent;
- (n) contaminated bedding and other material from the area must be disposed of after 24 hours,
- (o) entry to the area must be prohibited between the time of injection and the time of removal of the animal for the imaging procedure;
- (p) a syringe shield must be used for the injection of the radioactive technetium;
- (q) provision must be made for appropriate shielding of the operator at the imaging console;
- (r) the animal must be sedated as appropriate for the period of the imaging procedure; and
- (s) radiography or other clinical investigations required must be delayed until the day after the administration of the technetium.

Treatment of feline hyperthyroidism with iodine-131: Iodine is readily volatile and, if proper precautions are not taken, it is readily vaporised and can be inhaled and accumulate in the body. Also, vapours may build up in poorly ventilated areas thereby presenting a potential inhalation hazard to anybody in the vicinity.

C2.2 The following requirements must be implemented for the treatment of feline hyperthyroidism with iodine-131:

- (a) an isolated, shielded, well ventilated and secure area must be provided for:
 - (i) administering the radioactive material; and
 - (ii) hospitalising the cat for at least 5 days after the administration,
- (b) the radioactive material must be kept in a shielded container until just before administration;
- (c) if the radioiodine is injected either intravenously or subcutaneously:
 - (i) disposable gloves must be worn during the procedure; and
 - (ii) disposable gloves, the syringe barrel and any other item or material that might have become contaminated during the procedure must be stored as radioactive waste following the procedure¹⁷,

¹⁶ Production of radioactive urine in the imaging area could not only be hazardous but it could also interfere with the imaging process. Minimisation of urination can be, for example, achieved by the prior use of an appropriate diuretic.

¹⁷ Waste containing radioiodine should be stored for at least 6 weeks.

- (d) a well ventilated and shielded area must be available for storage of radioactive waste¹⁸;
- (e) all material removed from cages must be:
 - (i) handled with disposable gloves; and
 - (ii) stored as radioactive waste in accordance with detailed safety protocols;
- (f) a written protocol for the handling of radioactive material must include details of:
 - (i) routine radiation monitoring of the area after administration; and
 - (ii) clean up procedures and radiation monitoring after a spillage¹⁹;
- (g) at the time of release, the treating veterinary surgeon must provide the owner of the cat with plain-language, written instructions for the handling of the cat for the following two weeks that include:
 - (i) instructions to avoid long periods (more than a few minutes) in close proximity to the cat, particularly during the first week;
 - (ii) information that it is safe to pick up the cat for short periods but that it should not sit on any person's lap for extended periods or sleep next to any person on a bed;
 - (iii) instructions that if the cat:
 - A. urinates inside a dwelling, the urine should be cleaned up thoroughly with paper towels which are then placed in a rubbish bag; and
 - B. vomits inside a dwelling, the vomit should be cleaned up thoroughly with paper towels which are then placed in a rubbish bag;
 - (iv) instructions that the cat should only be handled in well ventilated areas during this period ;
 - (v) instructions to wear rubber gloves when cleaning up urine and to wash hands thoroughly afterwards; and
 - (vi) instructions that if the urine has soaked into garments or carpets, they should be cleaned thoroughly,
- (h) after administration:
 - (i) the cat must, where practicable, be:
 - A. handled with disposable gloves; and
 - B. held at arm's length; and
 - (ii) the treatment area and disposable gloves be monitored with an appropriate radiation survey meter,
- (i) an extraction fan must be installed unless there is good natural ventilation;

¹⁸ The urine may contain up to half of the administered radioactivity in the first 3 days.

¹⁹ Spillage of radioactive material could occur if the cat:

- bites and punctures a radioactive capsule; or
- regurgitates a capsule or its contents; or
- a syringe has its contents inadvertently expelled.

- (j) where the radioiodine is in capsule form:
 - (i) the cat must be:
 - A. lightly tranquillised²⁰; and
 - B. placed in a deep tray, such as a baby bath, lined with absorbent paper for administration of the radioactive material;
 - (ii) where possible, long handled forceps must be used to insert the capsule well down the throat followed by about 20 ml of water introduced into the mouth by a syringe; and
 - (iii) consideration must be given to the risk of subsequent vomiting by the animal,
- (k) if a cat dies before treatment is completed, it must be:
 - (i) sealed in a plastic bag;
 - (ii) stored as radioactive waste until it can be cremated or released for burial; and
 - (iii) cremated or released to the owner for burial after an appropriate decay time has been applied^{21,22}.

²⁰ Tranquillisation is inappropriate in cats that may be cardiac or renally compromised with hyperthyroidism.

²¹ The necessary period of time will be determined by the half life of the radionuclide used.

²² Where a post mortem examination is required, the procedures observed during post mortem examinations are normally adequate.

Schedule D

Radiotherapy

D1 PROCEDURES AND FACILITIES

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

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

- D1.1 Radiotherapy of animals must only be performed by, or under the direct supervision of, personnel:
- (a) specifically trained and experienced in such procedures; and
 - (b) who are appropriately authorised by the relevant regulatory authority.
- D1.2 The therapeutic use of radiation must only be undertaken using special equipment and facilities designed for the purpose.
- D1.3 The facilities for the treatment and housing of the animal must be adequate for protection of:
- (a) the persons caring for the animal; and
 - (b) any other person in the vicinity.

D2 X-RAY THERAPY EQUIPMENT

- D2.1 Each X-ray therapy machine must be:
- (a) designed specifically for therapy;
 - (b) designed so that:
 - (i) the air-kerma rate from leakage radiation through the X-ray tube housing and the beam defining applicators for every specified rating of the X-ray tube in the housing does not exceed:
 - A. 10 mGy.h⁻¹ at a distance of 1 m from the focus; or
 - B. 300 mGy.h⁻¹ at any accessible position at a distance of 0.5 m from the surface of the housing and the applicator,
 - (ii) the X-ray tube is mounted in a way that it cannot turn or slide in relation to the housing aperture.
 - (iii) a mark on the housing shows the location of the focal spot;
 - (iv) a suitable exposure control device (timer or exposure meter) is provided that terminates the exposure after a preset:
 - A. time interval; or
 - B. exposure limit,

- (v) an easily discernible indicator is provided on the control panel that shows when X-rays are being produced;
 - (vi) for apparatus capable of operating at X-ray tube voltages above 100 kV, interlocks are provided that:
 - A. prevent entry to the treatment room while the equipment is in operation;
 - B. interrupt the radiation treatment when the door to the treatment room is opened;
 - C. are of a fail-safe type;
 - D. are configured so that once the radiation treatment is interrupted by the operation of the interlock, it is only possible to finally restore the apparatus to full operation from the control panel; and
 - E. are tested and maintained at regular intervals for correct functioning;
 - (c) tested for performance and calibrated by a qualified expert:
 - (i) before it is first put into use for treatment;
 - (ii) annually thereafter; and
 - (iii) after any major overhaul or service.
- D2.2 The control station or control position for an X-ray therapy machine must be:
- (a) outside the treatment area; or
 - (b) behind an adequate protective barrier.
- D2.3 The control panel and the animal must be kept under observation during exposure.
- D2.4 The animal must be:
- (a) adequately immobilised for treatment; and
 - (b) observable from the control position.
- D2.5 No person is permitted to remain in the treatment area during the time the X-ray beam is on.
- D2.6 X-ray warning signs must be displayed at all entrances to the defined X-ray treatment area, room or enclosure (see Annex H).
- D2.7 X-ray therapy equipment must not be used to treat animals until the radiation safety of the installation has been established by a protection survey.

D3 SEALED RADIOACTIVE SOURCES – GAMMA-RAY EMITTERS

- D3.1 The storage and handling of the sources must be in accordance with the requirements of Annex E.
- D3.2 An up-to-date register must be maintained of all sealed radioactive sources that includes details of:
- (a) where appropriate, the serial number or other identification of each sealed radioactive source;

- (b) the physical or chemical form of the radioactive material;
 - (c) a photograph or diagram of the source;
 - (d) the date of receipt and its **activity** on that date; and
 - (e) the date and manner of ultimate disposal (including those sources permanently implanted in animals).
- D3.3 A radiation survey meter must be readily available that is:
- (a) in good working order; and
 - (b) suitable for the type of radiation being used.
- D3.4 An appropriate personal monitoring device must be worn by each person handling radioactive materials.
- D3.5 At all times during the use of removable sealed radioactive sources in treatment:
- (a) the animal must be housed:
 - (i) under regular supervision;
 - (ii) in strictly secure circumstances in an enclosure such as a kennel, box or stall, set aside for that purpose; and
 - (iii) so that escape of the animal with sources in situ is most unlikely;
 - (b) the enclosure must be located:
 - (i) in a position that is at least 3 metres from any normally occupied areas; and
 - (ii) as far as practicable from frequently used corridors, passageways or other thoroughfares;
 - (c) the sealed radioactive sources to be used must be taken into the enclosure in their shielded container and then applied directly to the animal;
 - (d) upon removal of the sources from the animal and before the animal is released from the enclosure, the sealed radioactive sources must be:
 - (i) checked;
 - (ii) all accounted for;
 - (iii) immediately returned into the shielded container; and
 - (iv) returned to the store,
 - (e) if any damage to sources is observed following removal from the animal, the person responsible for the radioactive sources must be notified as soon as possible;
 - (f) no person is permitted to enter the enclosure apart from essential feeding and care of the animal;
 - (g) if a radioactive mould or applicator slips or becomes dislodged, the operator must notify the veterinary surgeon responsible for the treatment of the animal as soon as possible; and
 - (h) appropriate radiation warning signs and instructions must be displayed on the enclosure.

- D3.6 In the case of permanent implantation of radioactive sources into an animal, the animal must be housed and attended to unless or until the total activity in the animal is less than:
- (a) for companion animals (i.e. domestic pets or animals normally in regular contact with humans), 1.2 GBq (~32 mCi) of gold-198; or
 - (b) for field animals (i.e. animals normally held in a paddock or very large yard and not in contact with humans), 6 GBq (~160 mCi) of gold-198.
- D3.7 For companion animals, the housing and care referred to in D3.6 above must be at the premises of the veterinary surgeon.
- D3.8 When the activity of the source is less than the values given in D3.6 above and the animal is released into the custody of an adult, that person must be provided with:
- (a) a suitably shielded container; and
 - (b) appropriate written instructions that:
 - (i) apart from essential feeding and care, persons not remain closer than one metre from the animal for 4 days after discharge of the animal;
 - (ii) no animal be ridden, groomed or have any extensive contact with humans until at least 14 days after discharge;
 - (iii) if any radioactive seed or grain from the implant becomes accidentally dislodged, it is only retrieved using tweezers, pliers or other long-handled implements, placed in the suitably shielded container referred to above and kept in safe custody until disposed of;
 - (iv) details of how to dispose of a source should it become dislodged; and
 - (v) on no account should any radioactive seed or grain be handled in the fingers or kept as a curio.
- D3.9 If an animal dies before treatment is completed, the person responsible for the radioactive material must:
- (a) be notified as soon as possible; and
 - (b) arrange for removal of the sources.

D4 SEALED RADIOACTIVE SOURCES – BETA PARTICLE EMITTERS

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

Use of an applicator

- D4.1 A strontium-90 applicator must only be used by a person appropriately authorised by the relevant regulatory authority to do so.

D4.2 The applicator must be fitted with an appropriate handling device for use.

D4.3 The active face of the plate must not be viewed directly.

Damage, loss or disposal of an applicator

D4.4 A plate that has been damaged in any way²³ must be returned immediately to an appropriate body for checking, possible repair and testing for radioactive leakage.

D4.5 The loss of an applicator must be reported to the relevant regulatory authority immediately.

D4.6 Strontium-90 applicators must only be disposed of subject to authorisation by the relevant regulatory authority.

Storage of strontium-90 applicators

D4.7 A strontium applicator must be stored in a container that is designed:

- (a) with the smallest overall external dimension of the box not less than 0.1 m;
- (b) to protect the plate from damage;
- (c) to provide adequate radiation shielding; and
- (d) so that the plate cannot move or be dislodged during transport.

D4.8 The plate must always be kept in its special container when:

- (a) not in use; or
- (b) being transported.

D4.9 The outside of the box must carry the:

- (a) appropriate radiation warning symbol;
- (b) name of the radioisotope (strontium-90);
- (c) nominal activity;
- (d) date of measurement; and
- (e) name, address and contact telephone number of the Responsible Person.

²³ For example, the boss broken off or the flat active section bent or scratched.

Schedule E

Lasers

E1 GENERAL REQUIREMENTS FOR PROTECTION

- E1.1 Class 4 and class 3B laser equipment must only be used subject to:
- (a) compliance with the provisions of Australian/New Zealand Standard AS/NZS 2211.1 – Part 10:2004 *Safety of laser products – Equipment classification, requirements and user's guide*;
 - (b) appropriate authorisation from the relevant regulatory authority;
 - (c) no person being exposed to laser radiation above the maximum permissible exposure levels;
 - (d) each operator of laser equipment having undertaken approved laser safety training;
 - (e) the laser apparatus not being modified;
 - (f) the development and documentation of safe working practices involving the use of laser apparatus; and
 - (g) all staff involved with the use of lasers being appropriately trained.
- E1.2 The laser facility must:
- (a) be adequately ventilated;
 - (b) have adequate opaque window coverings;
 - (c) have adequate fire suppression equipment; and
 - (d) be adequately signposted with an approved laser warning sign.

E2 PROTECTIVE EYEWEAR

- E2.1 Appropriate protective eyewear must be:
- (a) available; and
 - (b) worn by each person involved with a laser procedure.

(This page intentionally left blank)



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

SAFETY GUIDE

Radiation Protection in Veterinary Medicine

Radiation Protection Series Publication No. 17

(This page intentionally left blank)

Contents

1. Introduction	43
1.1 CITATION	43
1.2 PURPOSE.....	43
1.3 SCOPE	43
1.4 STRUCTURE.....	44
1.5 CATEGORIES OF EXPOSED PERSONS IN VETERINARY MEDICINE.....	44
1.6 RISK OF RADIATION INJURY IN VETERINARY MEDICINE	45
2. Responsibilities	46
2.1 THE RESPONSIBLE PERSON.....	46
2.2 THE VETERINARY SURGEON.....	50
3. Personal Radiation Monitoring	53
3.1 PERSONAL MONITORING DEVICES.....	53
3.2 RADIATION DOSE RECORDS	53
4. Radiation Incidents	54
4.1 MANAGEMENT OF AN INCIDENT	54
Annex A Radiation Safety Officer (RSO)	55
Annex B Procedure Rooms and Facilities	57
Annex C Strontium-90 Applicators	60
Annex D Survey Meters	64
Annex E Storage of Veterinary Sources of Radiation	65
Annex F Ancillary Equipment and Devices for Radiography	67
Annex G Guide to Manual Processing of Radiographs	69
Annex H Radiation Warning Labels and Notices	75
Annex I Health Effects of Ionizing Radiation and Standards for Control of Exposure	78
Annex J Lasers	81

(This page intentionally left blank)

1. Introduction

1.1 CITATION

This Safety Guide may be cited as the *Safety Guide for Radiation Protection in Veterinary Medicine (2009)*.

1.2 PURPOSE

This Safety Guide has been prepared as a supplement to the *Code of Practice for Radiation Protection in Veterinary Medicine (2009)* (hereafter called 'the Code'). It provides advice and guidance on good radiation practice and on meeting the requirements of the Code. Guidance is needed on the protective measures and procedures that should be adopted to ensure that such exposure is kept as low as reasonably achievable and below the limits prescribed.

The guidance offered in this Safety Guide is not mandatory. This Safety Guide does however, detail the measures that should be implemented in the safe use of radiation in veterinary medicine. It provides information to help obtain satisfactory clinical outcomes with minimum exposure to radiation of the animal, the clinician and other persons involved with the examination. It includes information on:

- allocation of responsibilities;
- clinical assessment of the indications for veterinary procedures using radiation;
- provision of appropriate facilities and ancillary equipment; and
- adoption of procedures to minimise exposure to radiation.

This Safety Guide is not a substitute for radiation protection legislation but should be studied in conjunction with it. Advice on this legislation and on any aspects of the implementation of this Safety Guide should be sought from the relevant regulatory authority.

1.3 SCOPE

This Safety Guide applies to the use of radiation in the practice of veterinary medicine, teaching and research and embraces diagnostic radiology, radiotherapy and nuclear medicine.

The Safety Guide provides guidance to meet the requirements in the Code for the following protective measures:

- allocation of responsibility for all safety procedures and radiation surveillance;
- provision of appropriate premises and installations;
- provision of appropriate radiation and ancillary equipment; and
- provision of appropriate maintenance and safety checking of equipment.

The application of these measures will ensure that the prescribed dose limits with respect to exposure of persons will not be exceeded and that any unnecessary exposure will be minimised.

This Safety Guide outlines measures that should be followed in the use of radiation in veterinary medicine. Nevertheless, practitioners should also adopt sound judgement in specific situations while implementing these measures. The Code requires that veterinary establishments:

- draw up their own detailed working procedures and a radiation management plan based on relevant legislation and this Safety Guide; and
- issue appropriate instructions to all workers who may be exposed to radiation in the course of their duties.

1.4 STRUCTURE

This Safety Guide sets out information that should assist in achieving a satisfactory level of radiation protection. While it does not form part of the material directly adopted into the regulatory frameworks of the State, Territory or Commonwealth authorities, it does set out best practice in veterinary medicine and therefore the use of this Safety Guide is recommended for establishing appropriate radiation protection procedures. The Safety Guide does not restrict users from developing their own institutional procedures that provide an equivalent level of safety to meet the requirements of the Code.

Material in this Safety Guide is advisory material for clarification and guidance.

1.5 CATEGORIES OF EXPOSED PERSONS IN VETERINARY MEDICINE

Radiation Protection Standards cover two categories of exposed persons. These are:

- persons occupationally exposed to radiation, i.e. all ionizing radiation exposures of persons that occur at their workplace; and
- members of the public, i.e. all exposures of persons that are not occupational (or medical).

Persons occupationally exposed to radiation include all members of a department or practice, including veterinary students and temporary or visiting staff whose duties are likely to require their presence during radiographic, radiotherapeutic or nuclear medicine procedures. Exposure of employees who have no direct involvement in work which requires exposure to radiation should be controlled, where possible, in a manner similar to that employed for members of the public. This may be achieved by adopting a dose constraint related to the public effective dose limit given in RPS1 in the design of the working environment for this category of employees.

Members of the public include all other persons, e.g. owners of animals, observers, and persons living adjacent to the premises where radiation is used.

1.6 RISK OF RADIATION INJURY IN VETERINARY MEDICINE

If the provisions of this Safety Guide are applied carefully and consistently, the dose limits will not be exceeded and the risk of radiation injury will be slight. However, injury may result if the dose limits laid down in the Radiation Protection Standards are exceeded:

- by a large factor in:
 - a single exposure; or
 - several exposures over a short period of time; or
- over a long period.

Attention is drawn to the manner in which the dose limits may be exceeded in relation to the veterinary practice.

In radiography, the principal hazard arises from the possibility of exposure to the primary X-ray beam. Scattered radiation and radiation leaking from the X-ray tube assembly, which are always present during an exposure, may also contribute further doses.

In nuclear medicine or radiotherapy using unsealed radioactive material (i.e. liquid solutions, gelatine capsules, gases or aerosols), there is the additional hazard of radioactive contamination that leads to potential inhalation or ingestion risks.

In radiotherapy, the radiation dose delivered to the animal is very much greater than in diagnostic procedures and thus the hazard may be very much greater to the operator.

2. Responsibilities

2.1 THE RESPONSIBLE PERSON

Although the Responsible Person may delegate some tasks to others such as a Radiation Safety Officer (RSO), the ultimate legal responsibility lies with the Responsible Person. Where the Responsible Person decides to appoint an RSO, the RSO will typically have the duties outlined in Annex A of this Safety Guide.

The radiation regulatory authorities in Australia require that all operators of radiation equipment and radioactive sources either hold a current authorisation to operate the equipment or be otherwise exempt.

Radiation Management Plan

Clause 3.1.1 of the Code requires that the Responsible Person has a Radiation Management Plan in place for the control of radiation exposure. The RSO, working closely with relevant staff, would normally develop the Radiation Management Plan. Both the Radiation Management Plan and its implementation require regular review. The Radiation Management Plan should include written procedures or protocols to address:

- work practices;
- a risk/hazard assessment for all radiation procedures carried out at the veterinary practice or installation;
- routine working procedures for radiography that are:
 - appropriate to the type of work carried out in the establishment;
 - followed by each person carrying out and assisting with radiography; and
 - posted in the X-ray areas.
- roles and responsibilities;
- radiation monitoring requirements;
- requirements for the control of an incident involving veterinary X-ray equipment or radioactive sources;
- requirements for the storage of veterinary X-ray equipment and radioactive sources;
- requirements for the transport of radioactive material;
- requirements for records of repairs and maintenance of veterinary X-ray equipment and radioactive sources;
- what to do with the veterinary X-ray equipment or radioactive sources (e.g. sale, transfer, disposal) when it is no longer required;
- records and accountability; and
- any other requirement that may have a bearing on safety.

The Radiation Management Plan may refer to and utilise other documented safety procedures and work practices that exist within the organisation.

The Radiation Management Plan requires that a suitable radiation survey meter that meets the requirements of Annex D of this Safety Guide is immediately available to monitor the gamma radiation levels for diagnostic and therapeutic nuclear medicine procedures. This may be achieved by borrowing, hiring or sharing a survey meter. Details of how the availability of the survey meter is to be achieved are to be included in the Radiation Management Plan. The borrowing, hiring or sharing of a survey meter does not alleviate the Responsible Person from the survey monitoring requirements of the Code.

Dose limitation

The Responsible Person should:

- identify all persons who are occupationally exposed to radiation; and
- make sure that suitable personal and other monitoring devices are:
 - provided;
 - kept in good working order;
 - properly used; and
 - calibrated.

Transport of radioactive material

The Responsible Person will need to make sure that the transport of radioactive material under their care on public roads, rail or inland waterways complies with the most recent edition of the **Transport Code**.

Incident control

The Responsible Person should ensure that:

- any unsafe practices or incidents are:
 - recorded; and
 - reported to the relevant regulatory authority,
- for nuclear medicine and radiation therapy, an emergency kit for dealing with any foreseeable incident is:
 - assembled; and
 - readily available for use; and
- medical services relevant to exposure to radiation are provided to staff and records of findings are kept where that does not impinge on the privacy of the individual.

Miscellaneous

The Responsible Person should ensure that:

- all staff are advised on safe working practices in accordance with all relevant:
 - legislation; and
 - Codes of Practice;
- all assistants receive clear instructions on the procedure to be undertaken and understand their part in it; and
- all controlled, supervised areas, equipment and operations are monitored and surveyed:
 - as necessary; and
 - upon request;
- records of all stocks and locations of radioactive materials and **irradiating apparatus** are:
 - maintained; and
 - available for inspection by the relevant regulatory authority;
- arrangements are in place for the safe:
 - storage of radioactive materials; and
 - disposal of radioactive waste;
- advice, instruction and local rules on radiation safety are provided:
 - in an easily understandable form; and
 - at an adequate level for all persons involved with the use of ionizing radiation, and
- any tasks that may be necessary to maintain a high standard of radiation safety in the establishment are performed.

Facilities, equipment and installations

The Responsible Person should provide all facilities and equipment necessary to enable the implementation of this Safety Guide.

The Responsible Person should keep plans for buildings incorporating radiographic, radiotherapeutic or nuclear medicine facilities that include:

- details of shielding; and
- other safety facilities.

The Responsible Person should ensure that the radiation shielding at the veterinary facility or practice meets the requirements of the relevant regulatory authority before a radiation installation is put into routine use.

Radiation safety assessments

The Responsible Person should make sure that a radiation safety assessment is carried out where:

- the installation or working procedures are to be modified such that there would be a change in:
 - the amount of radiation and the manner of its use;
 - the radiation source and ancillary equipment; or
 - the location of the radiation facility.

Such modifications may mean the original protection is no longer adequate.

- personal monitoring indicates that the doses received by any person:
 - exceed the appropriate dose limits or dose constraints;
 - are likely to exceed the appropriate pro-rata dose limits;
 - are higher than normal for no obvious reason; or
 - are higher than average doses received in similar departments and practices,
- changes are to be made in the immediate environs that may result in an increase of occupancy, such as a store or waiting area becoming an office;
- an increase in workload in the department or practice is anticipated;
- servicing has been carried out on a radiation source and its ancillary equipment; or
- a radiation source and its ancillary equipment is replaced or otherwise significantly modified.

Imaging requirements for radiography

The Responsible Person should make sure that, where possible, digital imaging receptors are used. Where digital imaging receptors are unavailable or cannot otherwise be used, the Responsible Person should make sure that:

- the fastest film and film-intensifying screen combination compatible with an acceptable image quality is used;
- in the case of veterinary dental procedures, the fastest available film compatible with an acceptable image quality is used;
- cassettes and intensifying screens, where used, are cleaned and maintained; and
- appropriate film processing facilities are available where required and are used correctly (see Annex G for information on the manual processing of radiographs).

2.2 THE VETERINARY SURGEON

Radiology procedures

The veterinary surgeon in charge of a radiology procedure should make sure that:

- no exposure is made until the animal is properly restrained and positioned;
- all practical precautions are taken to avoid unnecessary repetition of radiographs;
- the X-ray tube assembly is rigidly supported by a mechanical holder, stand or wall mounted arm that:
 - provides adequate stability; and
 - does not allow movement blurring of the radiograph.
- no person holds the X-ray tube assembly or the cassette during radiography unless the X-ray tube or the cassette is specifically made to be safely held by hand and:
 - there is otherwise significant risk of physical injury to personnel from the animal; or
 - the specific view required is not possible using other equipment configurations therefore necessitating the holding of the tube or cassette,
- the animal is not held for radiography unless for clinical reasons other means of immobilisation are not practicable. Immobilisation of animals should be achieved by one or more of mechanical means, tranquillisation or anaesthesia²⁴. These methods will:
 - eliminate or reduce the radiation hazard from manual restraint; and
 - assist in the reduction of image blurring due to movement.
- when, in exceptional circumstances, manual restraint is necessary, the following procedures are adopted:
 - the animal is restrained by the minimum number of persons necessary;
 - all persons position themselves as far as practicable from the path of the primary X-ray beam, the animal and the X-ray tube housing;
 - no part of any person is in the direct X-ray beam. In addition to the X-rays in the primary beam, X-ray leakage from the tube housing and X-rays scattered from the animal and any other objects in the path of the primary beam may be significant;
 - each person holding the animal wears protective gloves and an apron;

²⁴ Advice on mechanical restraints is given in Annex F.

- persons not normally occupationally exposed to ionizing radiation (for instance the owners of the animal) may be asked to hold the animal, provided that any reduction in control that results will not significantly increase the radiation hazard of the procedure;
- persons under the age of 18 years do not hold animals during radiography and a notice to this effect is displayed prominently in the X-ray area;
- during radiography, pregnant women:
 - remain at least 2 m from the edge of the beam; and
 - do not hold animals.

A notice to this effect should be prominently displayed in the X-ray area;

- when it is necessary for staff to hold an animal during radiography, wherever practicable, the same person is not always called upon to do this.

Radiography of large animals

Radiography of large animals generally requires the use of considerably greater exposure factors, thereby increasing the hazard from both the primary beam and scattered radiation. For a radiographic examination of a region of a large animal other than the lower limbs, the veterinary surgeon in charge of the procedure should ensure that:

- high-powered X-ray equipment at a fixed installation is utilised;
- all assistants wear sufficient protective clothing to give full protection from the source of radiation. For example, it may be necessary to protect the legs;
- all assistants not immediately required for the procedure remain as far away as practicable, and at least 2 m from the beam; and
- the animal is, whenever possible, suitably tranquillised or anaesthetised before radiography.

Radiography outside defined X-ray rooms

When radiography is carried out outside a defined X-ray room or area, the veterinary surgeon in charge of the radiology procedure should ensure that:

- all safety equipment provided by the Responsible Person is used;
- the number of assistants is kept to the minimum necessary for the procedure;
- the nature of the procedure and the precautions to be observed are explained to the assistants before the radiographic exposures are made;
- adequate precautions are taken to prohibit the access of unauthorised persons to the area during radiography. For example, by display of warning signs – see Annex H;
- adequate supports for the X-ray tube assembly and cassettes are used;

- the X-ray beam is correctly aligned to the cassette; and
- the X-ray beam is collimated to an area equal to or less than the cassette.

Fluoroscopy procedures

The veterinary surgeon in charge of a fluoroscopy procedure should make sure that no part of any person is exposed to the primary beam unless it is adequately shielded by protective clothing.

3. Personal Radiation Monitoring

3.1 PERSONAL MONITORING DEVICES

In addition to the requirements of clause 3.1.9 of the Code, the Responsible Person should provide an appropriate personal monitoring device to each person who:

- is involved in radiography of large animals. It should be noted that the probability of unintended exposure of personnel is increased during large animal radiography;
- is likely to be exposed to radiation from:
 - radioactive sources; or
 - therapy equipment,
- used in veterinary medicine.

The Responsible Person should make sure that the personal monitoring devices provided to each person are capable of measuring the type of radiation emitted by the veterinary radiation equipment or radioactive source being used.

Any person who is involved with the service or repair of veterinary radiation equipment or radioactive sources should wear an appropriate personal monitoring device at all times while that person may be exposed to radiation from the equipment or source.

3.2 RADIATION DOSE RECORDS

The Responsible Person should maintain radiation dose records for each person occupationally exposed to radiation that:

- show the doses assessed during the present period of employment; and
- are available for inspection by:
 - the individual to whom the record applies; and
 - the relevant regulatory authority.

4. Radiation Incidents

4.1 MANAGEMENT OF AN INCIDENT

In formulating the Radiation Management Plan, the Responsible Person should develop contingency arrangements detailing the action to be taken following all reasonably foreseeable incidents.

The Responsible Person should notify the relevant regulatory authority if a radiation safety assessment indicates that any person has or may have received doses in excess of the relevant effective dose limits or relevant dose constraints established.

Immediately following an incident, the Responsible Person should ensure that the relevant regulatory authority is informed:

- that the incident has occurred;
- of the steps that have been taken to rectify the situation; and
- of details of any radiation doses known, or suspected to have been received by any person.

Where a personal monitoring device is known to have or suspected of having received a radiation dose in excess of 1 mSv because of an incident, the Responsible Person should:

- submit the personal monitoring device of each person concerned for urgent assessment; and
- if being returned to a personal radiation monitoring service for assessment, advise the service of the circumstances of the known or suspected radiation dose.

Annex A

Radiation Safety Officer (RSO)

A person appointed as the Radiation Safety Officer should be thoroughly familiar with the:

- requirements of the relevant radiation safety legislation;
- provisions of the Code and this Safety Guide;
- Radiation Management Plan of the organisation;
- detailed working rules and emergency procedures adopted for use in accordance with the Code and this Safety Guide;
- radiation survey meters, where relevant;
- protective equipment; and
- personal monitoring devices used to meet the requirements of the Code and this Safety Guide.

Typically, an RSO will:

- maintain and regularly review the Radiation Management Plan;
- ensure that the facility meets the requirements of the Radiation Management Plan;
- advise on actions to be taken to reduce the radiation exposure of employees or members of the public to a level that is:
 - below the radiation protection limits prescribed in RPS1, and
 - as low as reasonably achievable, social and economic factors being taken into account.
- maintain the **occupational exposure** records;
- provide appropriate personal radiation monitors to staff;
- maintain radiation safety records;
- ensure that radiation monitoring instruments are regularly:
 - maintained,
 - calibrated, and
 - tested;
- ensure that all staff:
 - correctly use,
 - maintain, and
 - testpersonal protective equipment;
- be responsible for the:
 - initial and continued instruction of employees in radiation hazards,
 - safe working procedures to ensure radiation protection,
 - proper use of radiation monitoring and protective equipment, and
 - measures to limit radiation exposure;

- develop and implement safe work practices when using radiation sources;
- provide advice, as required, to the veterinary surgeon on radiation safety;
- ensure that all necessary:
 - shielding,
 - radiation safety equipment, and
 - radiation monitoring devicesare provided;
- carry out any measurements, investigations or assessments that are deemed necessary:
 - to verify radiation safety, or
 - in the event of a radiation incident;
- investigate any defect in an:
 - area, or
 - item of equipmentthat may increase the exposure of a person to radiation;
- recommend how to correct a defect;
- review, audit and report on radiation practices to ensure their continued effectiveness;
- provide reports on radiation incidents to the:
 - Responsible Person, and
 - relevant regulatory authoritythat include:
 - what happened,
 - estimates of radiation exposure to individuals,
 - action taken, and
 - recommendations on how to prevent a recurrence;
- ensure that prescribed radiation signs are:
 - maintained in good condition, and
 - located in places in which they will be readily seen;
- perform any other tasks required to maintain a high standard of radiation safety;
- ensure that:
 - satisfactory quality assurance (QA) programs, and
 - quality control (QC) testing for radiation safe practicesare performed; and
- maintain detailed records on all the above matters.

Annex B

Procedure Rooms and Facilities

B1 RADIOGRAPHY IN DEFINED X-RAY ROOMS OR AREAS

As far as practicable, all small animal radiography should be carried out in a defined X-ray room or area that has:

- sufficient space to take full advantage of distance and to allow full freedom of movement for:
 - the X-ray machine,
 - associated equipment,
 - the examination table, and
 - each person involved in the procedures;
- radiation shielding provisions for each person within and outside the room area;
 - a means of restricting access to the room or area;
 - X-ray warning signs at all entrances (see Annex H); and
- facilities for positioning and immobilising the animal.

At 2 metres from a veterinary X-ray unit, the dose received will generally be at background levels, even if several exposures are taken in a week. Therefore, many veterinary practices will have no need for any extra shielding. Ultimately, the amount of extra shielding required will be totally dependent on the workload. The need for structural shielding can however, be reduced by fixing the direction of the X-ray beam vertically downwards, if there is no occupied space beneath, with the animal placed on an X-ray table. Single clay brick walls, or equivalent, normally afford adequate protection from scattered radiation for adjoining areas. Where the beam can be turned in other directions additional shielding may be required.

B2 RADIOGRAPHY OUTSIDE DEFINED X-RAY ROOMS OR AREAS

Radiography of animals outside defined X-ray rooms or areas (in other parts of the premises, or on visits to farms, stables or kennels) is likely to add to the radiation risks for the following reasons:

- the usual ancillary and protective equipment may not be available;
- it is likely to be more difficult to immobilise the animal;
- the persons available to assist may be untrained or unaware of the hazards of radiation;
- it is likely to be more difficult to prevent the presence of unauthorised persons during radiography;
- there is a greater risk of irradiating persons in nearby areas; and
- the light beam collimator may be ineffective.

An X-ray examination should therefore not be carried out outside a defined X-ray room or area unless it is not practicable to bring the animal to that room or area. When radiography is carried out outside a defined X-ray room or area:

- the necessary equipment, such as cassette holders, should be available;
- lead backed cassettes or cassette holders should be provided;
- sufficient protective clothing should be available for all persons taking part; and
- adequate supports for the X-ray tube assembly and cassettes should be provided.

B3 VETERINARY DENTAL X-RAY EQUIPMENT

For dental examinations of small animals, a dedicated dental X-ray unit with appropriate cylindrical collimation should be used rather than a standard X-ray unit fitted with a LBC. The collimation of a dental X-ray unit will result in:

- more accurate positioning for the special views required in dentistry;
- fewer non-productive radiographs being taken; and
- less scattered radiation.

For large animals however, the use of a dedicated dental X-ray unit may not be practicable.

B4 ANCILLARY EQUIPMENT

An examination table should be provided with protective shielding equivalent to not less than 1.0 mm lead, or the nearest commercially available thickness e.g. 10 kg per square metre, underneath the tabletop or any Potter-Bucky diaphragm incorporated in the table. A tabletop of 5 mm steel is a satisfactory alternative. For ease of cleaning and to prevent mechanical damage, the lead shielding should be covered with laminated plastic sheeting.

Sand bags, V-troughs, slings, adhesive tape or other positioning and immobilising devices should be available for supporting the animal during radiography (see Annex F).

Suitable cassette holders should be available for use when using horizontal or angled X-ray beams.

Where cassette holders are not self-supporting, they should be fitted with:

- handles at least 1 metre long; and
- a ground support, to ensure that a person holding them can remain well outside the primary beam.

Personal protective devices such as aprons, gloves and shields suitable for hand and forearm protection should:

- be provided for all persons who are:
 - required to be present during radiography, and
 - not protected by fixed or mobile protective screens;
- have a lead-equivalent thickness throughout of not less than:
 - 0.25 millimetre, and
 - 0.5 millimetre when energies above 100 kVp are used;
- when not in use, be hung without folds on appropriate hangers.

Testing of personal protective devices should be carried out:

- at regular intervals of no more than 12 months; or
- more frequently if damage is expected.

If there is an indication of damage to a personal protective device, it should be examined radiographically or with a fluoroscopy X-ray unit to ensure that its shielding efficiency has not become impaired by cracks due to sharp folds, penetrations that could be caused by claws, animal bites or other damage. Records of any tests of personal protective devices should be kept.

B5 DIAGNOSTIC AND THERAPEUTIC NUCLEAR MEDICINE

All persons handling radioactive materials, animals, cages, food containers and excreta should wear gowns and disposable gloves. Excretion of radioactive materials may be via urine, faeces, saliva, exhaled breath or the skin.

Specially designed cages or other enclosures should be used to limit the spread of and contamination by the radioactive material.

B6 RADIATION THERAPY

Radiation therapy may be conducted within a special lead lined box that provides the same degree of attenuation as is required of the tube housing and accessory equipment.

For all radiation therapy procedures, access to the immediate area near the animal should be limited to about 15 minutes a day per person. Persons should not be permitted to stay within one metre of the enclosure unnecessarily. In particular, children, pregnant women and other members of the public should not remain in the vicinity during radiotherapy. Particular care should be taken in the:

- application of the sources; and
- care of the animal to safeguard the sources from dislodgment or damage during treatment;

Adequate arrangements should be provided for immediate response in case of an incident.

Annex C

Strontium-90 Applicators

DESCRIPTION OF APPLICATOR

Strontium-90 is a radioactive element with a **half-life** of approximately 28 years. In equilibrium with its decay product yttrium-90, beta radiation is emitted which has energy suitable for the treatment of very thin lesions.

The insoluble form of strontium-90 is incorporated in a rolled silver disc, which is embedded into a recess in a slightly larger metal disc. The strontium-90 disc is then covered by a thin protective metal foil window. The strontium-90 applicator or plate **is thus a disc with an 'active' front face made as thin as possible** to enable as many as possible of the beta particles to be emitted with minimal loss of energy, but adequate to prevent damage or loss of the strontium-90. This window is very delicate and should be treated with great care. There is an inactive border or margin 2-3 mm **wide surrounding the active area. The 'inactive' back of the plate is thick enough to absorb the beta particles.** A boss or lug to which a handle may be attached, is secured to the back of the plate. Although beta radiation is only emitted from the front face of the plate, X-radiation is produced in all directions by interaction of beta particles with the metal of the device and from surrounding materials. In addition, beta particles emitted from the front face may be back scattered from nearby materials.

Strontium-90 applicators are usually made as flat plates but some are fabricated into special shapes for particular purposes, such as for treatment of the eye. Normally the strontium-90 is uniformly distributed over the surface of the plate but for some specialised requirements an asymmetrical distribution may be used.

The dose rates from strontium-90 applicators vary considerably depending on the initial radioactive content and on the thickness of the window material, but can typically be up to 150 mGy.s⁻¹. Improper use may be injurious to the user and the animal. Nominally identical plates may have significantly different dose-rates. It is not possible to calculate the dose-rates of strontium-90 applicators from a knowledge of radioactive content. The dose-rate at the surface of the plate is usually specified as the surface dose-rate in tissue-equivalent material over the central area of the source. A Certificate of Measurement should accompany a new applicator when it is purchased. If there is no documentary evidence of the dose-rate then it should be measured by an accredited service. The dose rate is expressed in units of gray per second (or rad per second, 1 gray = 100 rad). The treatment time is calculated by dividing the desired surface dose by the dose-rate. In clinical applications, correct delivery of the prescribed dose is important and so it is necessary to use a stopwatch to measure the treatment time.

Some applicators are supplied with a 'cut-out mask' which may be fitted over the active face of the applicator to reduce the area to be treated. The use of the mask will reduce the surface dose rate to a considerable extent and a separate determination of the dose rate is required for use of the applicators when the mask is in place.

As the strontium-90 decays, the dose-rate from an applicator is reduced accordingly and thus the time to administer a given dose should be increased. The dose-rate should be re-determined at intervals not exceeding two years.

The dose delivered diminishes relative to that at the surface as the beta radiation penetrates through soft tissues. The following table indicates the dose at a depth as a percentage of the surface dose:

0.0 mm	100%
1.0 mm	65%
1.5 mm	50%
2.0 mm	35%
2.5 mm	25%

From consideration of this depth-dose effect, it is evident that the use of strontium-90 applicators is limited to the treatment of very superficial and thin lesions, typically those on the surface of the eye or very thin non-invasive lesions on the skin. It is not good clinical practice to attempt treatment of tissues situated more than 2 mm from the active surface of a strontium-90 applicator.

Strontium-90 applicators are very delicate devices and any mishandling, dropping, scratching, corrosion or other damage could cause a dangerous leakage of radioactive material and result in an uneven dose-rate from across the face of the plate. Strontium applicators should be checked for radioactive leakage using both wipe and immersion tests (as described in a recommended Standards publication), at regular intervals, not exceeding one year. It is important to note that:

- although the range of beta particles in tissue is only a few millimetres, the range in air is a few metres;
- the dose-rate is quite high and an applicator may be capable of delivering a therapeutic dose in less than one minute.

A statement of the current surface dose-rate for the particular strontium-90 applicator and a table of times for commonly used doses should always accompany the applicator in its storage box.

Sterilisation

A strontium-90 applicator should only be sterilised using cold sterilisation techniques.

Handling and care of strontium-90 applicators or plates

A strontium-90 applicator should always be manipulated using a permanently attached or long screw-in handle or long-handled forceps applied to the boss or lug on the back of the applicator. Forceps, scalpel blade or any other such instrument should not be used on the face of the plate.

A copy of the following notes should be included in the source container:

- A strontium plate emits very energetic beta particles from the front face of the plate. Personnel handling plates should take care to minimise their exposure to radiation.
- No significant beta radiation issues from the back of the plate although there is some X-radiation emitted in all directions.
- The plate is a delicate structure - any undue force applied to it may cause the boss or lug to break away from the active section.
- The plate should always be held with its active face away from one's person and in such a way that the face is not directed towards anyone else (except in its treatment role).
- If it is necessary to examine the active face of the plate during cleaning, it may be viewed using a non-metallic mirror.
- The material of the active face of the plate is very delicate and it should not be scratched or abraded.
- Sterilisation or asepsis may be achieved by immersion in a non-corrosive, non-sticky sterilising solution such as orthophthalaldehyde (Cidex OPA). The sterilising solution should then be thoroughly washed away with sterile water.
- During cleaning great care should be taken not to expose the fingers or any other part of the body to the direct radiation from the plate.
- The plate should be cleaned immediately after use in order to avoid biological matter drying and adhering to it. A thin film of dried material on the plate surface can significantly reduce the surface dose rate.
- If the plate is the type which has a cut-out mask fitted then this mask should be removed and cleaned separately.
- The plate should be cleaned by gently wiping with a swab or gauze moistened with distilled water. The swab or gauze should be placed on a flat surface and the plate wiped on it to avoid irradiating the fingers. (The plate should be kept at arms' length as much as possible.) If further cleaning is required then a mild detergent or ethanol may be used. Acid solutions should not be used.
- After cleaning, the plate should be completely dry before being replaced in its special container. Saline or sterilising solutions may cause corrosion to the container and damage to the plate.

Storage of strontium-90 applicators or plates

Some manufacturers supply strontium applicators in a specially designed box containing a support system and integral aluminium and lead shielding. In some cases, applicators are supplied in lead containers or pots which are not satisfactory as storage containers. In addition, the applicators are often wrapped in cotton wool, gauze or foam plastic. This material degrades from the effects of radiation and leaves a sticky deposit that may adhere to the delicate active surface of the applicator.

A container should be used in which the beta particles are absorbed firstly in a material of low atomic number e.g. aluminium, before using lead as a radiation shield. Beta particles absorbed directly in lead give rise to more secondary X-radiation of higher energy than in the case of absorption in aluminium.

A suitable container consists of an inner section of aluminium of at least 5 mm thickness. Materials such as wood (masonite), silicones, perspex etc. are unsuitable as they degrade under beta radiation and may cause damage to the active face of the applicator. The outer shield of the container should be at least 3 mm of lead.

The plate should be securely held in place so that the delicate active window is not in contact with any material. This may be achieved either by suspending the plate by the handle or by supporting it on an annular ring or ledge which makes contact only with the inactive border of the front face. (A neoprene 'O-ring' of appropriate size is quite suitable).

Such a container is satisfactory for clinical use but it may not be adequate for transport unless it is housed in or integral with an outer container or transport box.

A type of outer container suggested is a lockable metal 'deed' or 'cash' box in which the shielded container described above can be held firmly in a central location by a block of material such as foam plastic.

The box may also house accessories used in treatment such as handles, forceps, stopwatch, dose data tables, handling notes, etc.

The box should be stored at least two metres away from any commonly occupied work area and from any undeveloped film. The storage area should be a locked cabinet or safe with the appropriate warning sign and wording as specified in Annex H.

Transport of strontium-90 applicators or plates

An applicator could be handled by unsuspecting persons for extended periods due to a motor vehicle accident, or theft, during which significantly hazardous exposures might occur. If the applicator is to be transported by vehicle on public roads, the most recent edition of the Transport Code will need to be followed.

The box should be located as far as possible from the occupants of the vehicle and secured in position.

Annex D

Survey Meters

D1 GENERAL REQUIREMENTS OF THE SURVEY METER

A radiation survey meter should:

- have sufficient measurement range to measure **ambient dose equivalent** rates or **directional dose equivalent** rates, as appropriate, at least throughout the ranges of $1 \mu\text{Sv h}^{-1}$, or its equivalent, to $500 \mu\text{Sv h}^{-1}$, or its equivalent, for the radiations emitted from the radioactive sources used in veterinary medicine;
- continue to indicate, either visibly or audibly, when radiation levels exceed the maximum reading in any measurement range; and
- indicate the measured quantity with a measurement uncertainty not greater than ± 25 per cent inclusive of uncertainty due to response variation with energy over the range of energies of the radiation to be measured.

D2 CALIBRATION OF THE SURVEY METER

A radiation survey meter should:

- have a calibration check each year. A calibration check is a comparison of the dose rate from the survey meter against a known radioactive source or against another survey meter that is appropriately calibrated; and
- be calibrated:
 - before initial use;
 - at intervals not exceeding three years;
 - following damage or repairs; and
 - when otherwise indicated by its performance.

The calibration of a radiation survey meter should be, in the case of X-ray and gamma radiation, traceable to:

- the Australian National Standard of air kerma;
- a foreign reference Standard of air kerma recognised by the Chief Metrologist²⁵; or
- a National Standard of a country with which Australia has an arrangement for that Standard.

²⁵ The Chief Metrologist is defined under section 18A of the *National Measurement Act 1960*.

Annex E

Storage of Veterinary Sources of Radiation

E1 STORAGE OF RADIOACTIVE SOURCES USED IN VETERINARY MEDICINE

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

- is not required for immediate use; or
- has been removed from use.

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

- the radioactive source should be stored so that the likelihood of damage to the source is minimised. Damage to a gauge in storage could result from a fall, collision, corrosion etc.;
- the source container should be clearly labelled as containing a radioactive source;
- the source container should be locked or otherwise secured; and
- the source container should be monitored to ensure that:
 - the source is actually inside the container; and
 - the dose rate at the surface of the container will not result in any person exceeding the relevant dose limit specified in RPS1.

A store used for radioactive sources should:

- be of solid construction and made of durable materials;
- be designed, located, constructed and, if necessary, shielded so that:
 - the radiation levels at any accessible place outside the store do not result in an ambient dose equivalent rate or directional dose equivalent rate, as appropriate, exceeding $10 \mu\text{Sv}\cdot\text{h}^{-1}$;
 - no person will receive a radiation dose in excess of the appropriate limit specified in RPS1;
 - the resultant radiation dose rate in any occupied area is as low as reasonably achievable; and
- be under the control of a person nominated by the Responsible Person;
- be kept locked;
- be subject to strict access control;
- not be used for other purposes; and
- bear a conspicuous notice displaying the radiation hazard warning symbol, when a radioactive source is in the store. The letters and symbol of the notice should be in black on a yellow background. An example of a suitable notice is given in Annex H of the Safety Guide.

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

- near to explosives, combustible or corrosive materials or photographic or X-ray film;
- in an area prone to flooding or other potential hazard that may damage the store and/or its contents; or
- in an area that allows unrestricted access to the public.

E2 STORAGE OF VETERINARY EQUIPMENT FITTED WITH AN X-RAY TUBE

Veterinary equipment fitted with an X-ray tube should be stored:

- so that the tube cannot be energised;
- in an area, room or, in the case of an X-ray unit being used in the field, a vehicle that can be kept locked; and
- under the control of a person nominated by the Responsible Person.

Strict access control should be exercised over a store that contains veterinary equipment fitted with an X-ray tube.

Annex F

Ancillary Equipment and Devices for Radiography

To position the animal correctly for radiography special devices should be used to reduce to an absolute minimum the number of occasions on which it is necessary for the animal to be held by hand.

The following devices will be found useful:

Small animal radiography

- *Adhesive tape, gauze bandages*
Various types of tape and bandaging may be tied around, or placed over, an anatomical region to fix it in position for radiography. They may also be used to remove an overlying anatomical region from the area of interest.
- *Sand bags*
The sand should be contained in a sealed bag with an outer cover that can be removed for cleaning. The bags should be made in a variety of sizes so that they can be placed over a limb, or used as a 'prop', to position an area for radiography.
- *Positioning troughs*
These can be made of timber, perspex, or other sheet or foam plastic material. Usually, they are approximately V-shaped and may be constructed with adjustable sides. They are particularly useful for maintaining the animal in position for ventro-dorsal projections.
- *Radiolucent pads*
Radiolucent pads, foam plastic or rubber that does not impede passage of X-rays, can be purchased in a variety of shapes and sizes and may be used to position the animal correctly. Plastic bags filled with cotton wool will serve the same function.
- *Cassette holders*
These may be simple devices, such as a welding clamp with a handle that can be attached to the cassette. Alternatively they may be of a 'picture-frame' design, permitting the cassette to be slipped into a frame, to which a handle is attached. Adjustable cassette holders which may be clamped to the edge of the examination table are very useful. A wall mounted cassette holder, adjustable in the vertical direction, can be used for standing lateral radiographs.
- *Other devices*
The animal can also be positioned using compression bands (fitted to some X-ray tables), mouth gags, and suction cups that can be firmly fastened to the table (the cups may hold metal rods or padded metal plates that can be used to support the animal). Birds or small mammals may be restrained by placing them inside a short length of plastic tubing or piping with suitable ventilation.

Large animal radiography

- *Cassette holders*
In radiography of the distal limbs of standing animals, a cassette holder may be used that is of a similar design to that described for small animal radiography, provided the handle is of sufficient length to ensure that the hand and body of the holder are outside the primary X-ray beam.

In radiography of areas of the standing animal, other than the distal limb, the cassette should be placed either on a mobile stand that can be positioned beside the animal, or in a wall mounted cassette holder.

- *Other devices*
Blocks of wood, including blocks for examination of the equine navicular bone, will be especially useful in positioning the hoof for radiography. In the anaesthetised animal, ropes and hobbles, and metal 'props' should be used to assist in positioning an area for radiography.

Annex G

Guide to Manual Processing of Radiographs

This information has been prepared for persons processing radiographic films manually. Too great an emphasis cannot be placed on the need for high standards of practice in the processing of radiographs. High standards of processing contribute to better quality films for diagnostic purposes and to the elimination of one cause of avoidable repeat radiographic examinations which result in additional unnecessary radiation exposure, both to veterinary staff and assistants.

The quality of a finished radiograph depends upon several factors, such as:

- radiographic technique;
- area being examined;
- animal size;
- exposure factors;
- type of film (or film-screen combination);
- processing; and
- accessories such as a bucky or fixed grid.

To produce high quality films it is of the utmost importance that as many of these factors as possible be standardised. Although animals will vary a great deal and exposure will have to vary to compensate, *all* processing factors should be constant.

To obtain radiographs of a uniformly high quality it is important that exposed films be processed under reproducible conditions with respect to:

- concentration of chemical components;
- temperature of solution;
- time of development; and
- development techniques.

In relation to the time-temperature relationship, the use of a fixed temperature and a fixed time of development is strongly recommended. If a fixed temperature is not achieved, it is important that the temperature of the developing solution be measured and a time of development employed appropriate to that temperature. This is calculated from a time-temperature chart recommended by the manufacturer for the developer.

The optimum quality with respect to detail and contrast of a radiograph cannot be achieved without proper processing. Unsatisfactory processing of an exposed film will result in a radiograph of less than optimal quality which may result in either an incorrect diagnosis or an unnecessary repeat exposure. Incorrect exposure technique in radiography should not be compensated for by adjusting processing procedures. Adjusting processing procedures in an attempt to correct for over-exposure of a radiograph can lead to persistent errors in exposure techniques. A film which has been over-exposed and under-developed will not only be of less than optimal quality but will have been obtained with the staff having received more radiation than necessary.

Attention should be directed towards:

- the organisation of the work in the darkroom to avoid damage to films;
- the use of appropriate safe-lights for the type of film being used and testing the safe-lights for film fogging;
- the proper storage of unexposed film away from heat, radiation and chemical contamination;
- the use of film on a first-in, first-out basis to minimise the use of old stock;
- the regular replenishment of processing solutions; and
- following the procedures outlined below with respect to developing, fixing, washing and drying of films.

Ideally, the following facilities should be available:

- Light-proof darkroom:** Exclude all white light.
- Processing unit:** Developer, rinse, fixer, wash tanks.
- Drying cabinet:** Variable heat control, timer, racks.
- Safe-Lights:** As recommended by the film manufacturer.
- Thermometer:** Not mercury.
- Developer heater:** For example, an adjustable temperature tropical aquarium heater. This should be used in conjunction with a core balance leakage circuit breaker to minimise the risk of electric shock. It should be noted that the glow from some heater elements can cause light fogging on the films being developed.
- Timer:** Simple 60 minute timer with alarm.
- Film hangers:** Tension type to fit all film sizes and tanks.
- Adequate plumbing:** Ideally, hot and cold running water.
- Adequate drainage**
- Chemicals:** Developer, fixer, developer replenisher, wetting agent. Mix to manufacturer's instructions.
- Chemical stirring rods:** 2 PVC or stainless steel rods. Use one for developer and one for fixer. Do not interchange.
- Workbench:** Flat smooth surface for film and cassette handling.
- Adequate film storage**
- away from radiation;
 - no temperature excesses;
 - dry area; and
 - store on edge in light-proof containers – resealable, or a film hopper.

Processing guide:

1. Remove the film from the cassette and then write (with pencil) or print, using actinic marker, the animal and owner's name and the date on the film.
2. Attach the film to the correct size hanger – clipping the lower edge first.
3. Check developer temperature, set the timer for the recommended time, and place the film in the developer.
4. Agitate the film using a vertical motion when first placed in the tank and 3 or 4 times during the developing period. Attempt to do this without lifting film out of the solution.
5. When the timer rings, quickly remove the film and allow it to drain over the rinse tank NOT over the developer.
6. Rinse the film for 15 seconds in rinse tank and clean running water and then drain back into the rinse tank.
7. Place the film in the fixer tank and again agitate a number of times - particularly during the first minute of fixing.
8. Leave the film in the fixer for at least twice the time it takes to clear the unexposed sections (normally 4-6 minutes in all). The film should not be left in the fixer for more than 15 minutes.
9. Allow the fixer to drain back into the fixer tank and then place the film in clean running water for several minutes. Make sure there is space between each film and that the entire hanger is covered during washing.
10. Briefly rinse the film in a small tank of water containing a wetting agent solution. Drain the films and hang to dry – warm moving air is most effective.

NOTE: Steps 1 - 8 should be carried out under safe-light conditions.

Additional processing hints

- Keep hands dry when handling films.
- Avoid splashing chemicals (causes contamination).
- Replenish tanks regularly.
- Cover tanks with lids when not in use – retards oxidation of the developer and keeps dust from all solutions.
- Ensure that films do not touch each other, other hangers or the sides of the tanks during processing.
- Most importantly, keep the darkroom CLEAN AND TIDY.
- Always stir developer with Developer Stick and fixer with Fixer Stick before processing.
- Load and unload cassettes as far away from wet solution tanks as is practical to avoid marking films and staining intensifying screens.

Care of the chemicals

Developer

- Temperature* 20°–24° C is the usual range.
- Development Time* The manufacturer will supply a chart which gives the ideal temperature and the time for which film should be developed at that temperature. Follow this recommendation carefully.
- Stir* Before using, with a 'Developer Only' stirrer.
- Replenish* Low level should be topped up with freshly mixed replenisher. Mix only one litre at a time. Total replenishment should not exceed twice the volume of the tank. (Replace developer after this).
- Replace* Developer should be routinely changed once every 8 weeks, or earlier, if it is contaminated (e.g. oil slick on surface or milky appearance of solution).
- Mixing* Check the volume of the tank and mix strictly to manufacturer's recommendations. Always mix developer *after* fixer. Contamination of developer is a greater problem.

Rinse

- Temperature* As for developer.
- Time* 15 seconds.
- Water* Should be clean and running – at least 8 changes per hour.

Fixer

- Temperature* As for **developer**.
- Time* At least twice the clearing time (loss of milky appearance of film) which should not exceed 3 minutes, i.e. 6 minutes in all. Leaving the film in the fixer longer than 15 minutes may result in bleaching.
- Stir* Before using, with a 'Fixer Only' stirrer.
- Replenish* When the clearing time is greater than 2½ minutes, remove 5 litres from the tank and replace with 5 litres of freshly mixed replenisher.
- Replace* When clearing time is over 3 minutes or at least every 6 months.
- Mixing* Check the volume of the tank and mix strictly to the manufacturer's instructions. Always mix fixer before developer.

Wash

<i>Temperature</i>	As for developer.
<i>Time</i>	30 minutes.
<i>Water</i>	Should be clean (fit to drink) and running – at least 8 changes per hour.

NOTE:

All solutions should be approximately the same temperature, though only the developer is critical.

When solutions are changed, the tanks should be thoroughly cleaned – a hard plastic scourer, not likely to scratch the surface, should be used (steel wool and abrasive powders should not be used).

To stop algae build-up in the rinse and wash tanks, they should be drained frequently, cleaned and allowed to dry overnight.

Viewing boxes should not be placed above processing tanks as splashing of fixer into developer should be avoided.

To calculate volume of tanks

Fill empty tank with water from a measured container (e.g. 2 litre jug) and record volume;

OR

Measure internal dimensions in centimetres and substitute in the equation:

$$\text{Volume (in litres)} = \frac{\text{Depth} \times \text{Width} \times \text{Length}}{1000}$$

To test light-proofness of darkroom

Turn off all darkroom lights and remain in the completely darkened room for 10 minutes. Look around the room for tiny spots of light and mark them with chalk. Repair holes or patch them with black electrical tape.

To test safeness of safe-lights

1. Physically examine filter and housing for cracks or white light leaks. Check that globe is 25 watts or less (preferably 15 watts).
2. In total darkness load sheet of X-ray film into cassette; expose cassette to 50 kVp at a focus film distance of 1.0 m and preferably in the range of 1-4 mAs.
3. Turn off all darkroom lights, remove film from cassette and place film on bench top.
4. Cover one half of the film with a piece of cardboard.
5. With a second piece of cardboard cover all but 2 cm of the film.

6. Turn the safe-light on. Every 30 seconds move the second piece of cardboard so that it exposes an additional 2 cm of film to the safe-light.
7. Turn off the safe-light at the end of the last 30 second period and process the film in total darkness.
8. Safe-lights can only be considered safe for a period of exposure corresponding to the area that shows no significant difference in blackness from the area exposed only to radiation.
9. If the handling time in the darkroom is longer than the safe period (see 8):
 - replace globe with lower wattage;
 - direct safe-light at the wall or ceiling; and/or
 - replace filter according to film manufacturer's recommendations; and always
 - retest

Further information

All film and chemical manufacturers will supply, usually free of charge, excellent publications that explain image formation, darkroom practice, care of films and similar topics. Ask your supplier.

Annex H

Radiation Warning Labels and Notices

Radiation warning signs and notices, should conform to AS 1319 – 1994 *Safety signs for the occupational environment*, and AS 2342 – 1992 *Development, testing and implementation of information and safety symbols and symbolic signs*. Examples of suitable warning notices are given below.

H1 COLOURS FOR RADIATION WARNING LABELS AND NOTICES

Colours for radiation warning labels and notices

Background: yellow
Marking and trefoil: black

H2 EXAMPLES OF A SUITABLE WARNING NOTICE FOR THE ENTRANCE TO AN X-RAY ROOM



H3 EXAMPLES OF A SUITABLE WARNING NOTICE FOR THE ENTRY TO AN AREA WHERE RADIATION SOURCES ARE IN USE



H4 EXAMPLE OF A SUITABLE WARNING NOTICE FOR A STORE FOR RADIOACTIVE MATERIALS



Annex I

Health Effects of Ionizing Radiation and Standards for Control of Exposure

It is well known that high doses of ionizing radiation can cause harm, but there is continuing scientific uncertainty about effects at low doses. At levels of dose routinely encountered by members of the public and occupationally exposed persons, there is little or no epidemiological evidence of health effects. Radiation protection standards recognise that it is not possible to eliminate all radiation exposure, but they do provide for a system of control to avoid unnecessary exposure and to keep doses in the low dose range.

Extreme doses of radiation to the whole body (around 10 sievert²⁶ and above), received in a short period, cause so much damage to internal organs and tissues of the body that vital systems cease to function and death may result within days or weeks. Very high doses (between about 1 sievert and 10 sievert), received in a short period, kill large numbers of cells, which can impair the function of vital organs and systems. Acute health effects, such as nausea, vomiting, skin and deep tissue burns, and impairment of the body's ability to fight infection may result within hours, days or weeks. The extent of the damage increases with dose. However, '**deterministic**' effects such as these are not observed at doses below certain thresholds. By limiting doses to levels below the thresholds, deterministic effects can be prevented entirely.

Doses below the thresholds for deterministic effects may cause cellular damage, but this does not necessarily lead to harm to the individual: the effects are probabilistic or 'stochastic' in nature. It is known that doses above about 100 millisievert, received in a short period, lead to an increased risk of developing cancer later in life. There is good epidemiological evidence – especially from studies of the survivors of the atomic bombings - that, for several types of cancer, the risk increases roughly linearly with dose, and that the risk factor averaged over all ages and cancer types is about 1 in 100 for every 100 millisievert of dose (i.e. 1 in 10 000 per millisievert).

At doses below about 100 millisievert, the evidence of harm is not clear-cut. While some studies indicate evidence of radiation-induced effects, epidemiological research has been unable to establish unequivocally that there are effects of statistical significance at doses below a few tens of millisieverts. Nevertheless, given that no threshold for stochastic effects has been demonstrated, and in order to be cautious in establishing health standards, the proportionality between risk and dose observed at higher doses is presumed to continue through all lower levels of dose to zero. This is called the linear, no-threshold (LNT) hypothesis and it is made for radiation protection purposes only.

There is evidence that a dose accumulated over a long period carries less risk than the same dose received over a short period. Except for incidents and medical exposures, doses are not normally received over short periods, so that it is appropriate in determining standards for the control of exposure to use a risk factor that takes this into account. While not well quantified, a reduction of the high-dose risk factor by a factor of two has been adopted internationally, so that for radiation protection purposes the risk of radiation-induced fatal cancer (the risk factor) is taken to be about 1 in 20 000 per millisievert of dose for the population as a whole.

If the LNT hypothesis is correct, any dose carries some risk. Therefore, measures for control of exposure for stochastic effects seek to avoid all reasonably avoidable risk.

²⁶ The sievert (Sv) is a unit of measurement of radiation dose (see ARPANSA's *Recommendations for limiting exposure to ionizing radiation (2002)*).

This is called optimising protection. However, risk in this sense may often be assessed in terms of risk to a population, and may not ensure sufficient protection of the individual. Consequently, the optimisation approach is underpinned by applying dose limits that restrict the risk to individuals to an acceptable level. The fundamental regulatory philosophy is expressed in three principles, based on the recommendations of the International Commission on Radiological Protection (ICRP), which may be summarised as follows:

Justification: human activities that cause exposure to radiation may be permitted only if they do more good than harm;

Optimisation of protection: exposure to radiation from justified activities should be kept as low as reasonably achievable, social and economic factors being taken into account; and

Limitation of individual dose: doses should not exceed the prescribed dose limits.

Determining what is an acceptable risk for regulatory purposes is a complex value judgement. The ICRP reviewed a number of factors in developing its recommendations, which have in general been internationally endorsed, including by the World Health Organization, the International Labour Organisation and the International Atomic Energy Agency. Australia's Radiation Health Committee, now established under the ARPANS Act²⁷, has recommended that the international standards be adopted in Australia. The recommended dose limits are summarised as follows:

Limit on effective dose*

	For occupational exposure	For members of the public
To limit individual risk	20 mSv per year, averaged over 5 years*	1 mSv in a year*

*for details, see ARPANSA's *Recommendations for limiting exposure to ionizing radiation* (2002)

In most situations, the requirements for limiting individual risk ensure that doses are below deterministic thresholds, but for cases where this does not apply, the recommended limits are as follows:

Annual limit on equivalent dose*

	For occupational exposure	For members of the public
To prevent deterministic effects		
in the lens of the eye	150 mSv	15 mSv
in the skin	500 mSv	50 mSv
in the hands and feet	500 mSv	—

*for details, see ARPANSA's *Recommendations for limiting exposure to ionizing radiation* (2002)

In the case of occupational exposure during pregnancy, the general principle is that the embryo or fetus should be afforded the same level of protection as is required for a member of the public. For medical workers, the ICRP recommends that there

²⁷ The Australian Radiation Protection and Nuclear Safety Act (1998).

should be a reasonable assurance that fetal dose can be kept below 1 mGy²⁸ during the course of the pregnancy. This guidance may be generalised to cover all occupationally exposed pregnant workers by keeping the fetal dose below 1 mSv. A full explanation of radiation protection principles and of the recommended standards for Australia is given in ARPANSA/NOHSC Radiation Protection Series No. 1: *Recommendations for limiting exposure to ionizing radiation (1995)* and *National standard for limiting occupational exposure to ionizing radiation* (both republished in 2002).

²⁸ The gray (Gy) is a unit of radiation dose. For X-rays and gamma radiation, it is essentially equivalent to the sievert.

Annex J

Lasers

J1 INTRODUCTION

There is an increasingly widespread use of lasers for various applications in veterinary medicine. Lasers do not emit ionizing radiation but laser radiation is potentially hazardous to operators and to persons viewing the direct light beam or its reflections. Many lasers are capable of inflicting biological damage, mainly burns, with the eye and skin being most susceptible to laser injury.

The possession and use of certain lasers may be subject to control by the relevant regulatory authority and individual users may be required to hold a licence.

J2 DESCRIPTION

Lasers differ from all other sources of light both in the mechanism of operation and in the quality of the light produced. Lasers emit light either continuously (continuous wave or cw lasers) or in pulses. This light is generally either monochromatic or consists of a number of specific wavelengths within a beam of low divergence, i.e. well collimated and high power density (irradiance) often many times brighter than the sun. As an example, a low powered (5 mW) gas laser can have an apparent brightness (radiance) 1000 times greater than the sun. Laser wavelengths range from the ultraviolet through the visible to the far infrared regions of the spectrum.

J3 HAZARDS

Lasers that produce radiation in the visible and near infrared regions of the spectrum are particularly hazardous to the eye. This is because the eye will focus the laser beam on to the retina and a retinal burn may result in much the same way as a magnifying glass using the sun's rays can burn a hole in paper. The power density of the laser beam image formed on the retina is typically of the order of 100 000 times the power density of the laser beam at the cornea.

A retinal burn or lesion may result in serious and permanent impairment of vision or even blindness in the eye affected. A visual decrement resulting from a small lesion will usually be noted subjectively by an exposed individual only when the central region of the retina is involved. The damage appears initially as a blurred white spot obscuring the central area of vision but within two or more weeks it changes to a black spot. Ultimately, the victim may cease to be aware of this blind spot during normal vision. However, it can be revealed immediately in looking at an empty visual scene such as a blank sheet of white paper. Lesions occurring in the peripheral field of vision will be registered subjectively only when gross retinal damage has occurred. Small peripheral lesions may pass unnoticed and may not even be detected during a systematic eye examination.

The exposure time required to produce a serious lesion depends on many factors, but for many lasers exposure times of a fraction of a second can produce such a lesion and for such lasers, the blink reflex cannot therefore be relied upon to provide protection.

For most laser wavelengths, biological damage occurs principally through the heat generated by the interaction of light with matter. Ultraviolet radiation will interact directly with organic molecules to cause cell damage in addition to the heat

mechanism of damage. Very high power lasers may also produce a thermally induced sonic shock wave that may damage tissue some distances from the site of beam exposure by physical displacement of the tissue.

In addition to the hazards of exposure to the direct laser beam, exposure to its specular reflections caused by smooth reflecting surfaces, such as mirrors and lenses, is often hazardous, depending upon the amount of electromagnetic energy reflected. Diffuse reflections may also be hazardous when the reflected electromagnetic energy is sufficiently intense.

J4 PROTECTION

The potential hazards of lasers are outlined in Australian/New Zealand Standard AS/NZS 2211.1:1997 *Laser Safety Part 1: Equipment classification, requirements and user's guide*. This Standard also details the precautions to be taken by employers and gives permissible limits of exposure to laser radiations.

Additional reference should also be made to Australia/New Zealand Standards:

- AS/NZS 3200.2.22:1997 Approval and test specification – Medical electric equipment Part 2.22 – Diagnostic and therapeutic laser equipment; and
- AS/NZS 4173:2004 Guide to the safe use of lasers in health care.

J5 LASER SAFETY OFFICER

A Laser Safety Officer (who may also be the Responsible Person) knowledgeable in laser safety issues should be appointed to supervise the use of laser equipment.

Regulatory Authorities

Where advice or assistance is required from the relevant regulatory authority, it may be obtained from the following officers:

COMMONWEALTH, STATE/TERRITORY	CONTACT
Commonwealth	Chief Executive Officer ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au Tel: (02) 9541 8333 Fax: (02) 9541 8314
New South Wales	Manager Hazardous Materials and Radiation Section Department of Environment and Climate Change PO Box A290 Sydney South NSW 1232 Email: radiation@environment.nsw.gov.au Tel: (02) 9995 5000 Fax: (02) 9995 6603
Queensland	Director, Radiation Health Unit Queensland Health PO Box 2368 Fortitude Valley BC QLD 4006 Email: radiation_health@health.qld.gov.au Tel: (07) 3328 9987 Fax: (07) 3328 9622
South Australia	Director, Radiation Protection Division Environment Protection Authority GPO Box 2607 Adelaide SA 5001 Email: radiationprotection@epa.sa.gov.au Tel: (08) 8463 7814 Fax: (08) 8124 4671
Tasmania	Senior Health Physicist Radiation Protection Unit Department of Health and Human Services GPO Box 125B Hobart TAS 7001 Email: radiation.protection@dhhs.tas.gov.au Tel: (03) 6222 7256 Fax: (03) 6222 7257
Victoria	Team Leader, Radiation Safety Department of Human Services GPO Box 4057 Melbourne VIC 3001 Email: radiation.safety@dhs.vic.gov.au Tel: 1300 767 469 Fax: 1300 769 274
Western Australia	Secretary, Radiological Council Locked Bag 2006 PO Nedlands WA 6009 Email: radiation.health@health.wa.gov.au Tel: (08) 9346 2260 Fax: (08) 9381 1423
Australian Capital Territory	Director Health Protection Service ACT Health Locked Bag 5 Weston Creek ACT 2611 Email: hps@act.gov.au Tel: (02) 6205 1700 Fax: (02) 6205 1705
Northern Territory	Manager Radiation Protection Radiation Protection Section Department of Health and Families GPO Box 40596 Casuarina NT 0811 Email: envirohealth@nt.gov.au Tel: (08) 8922 7152 Fax: (08) 8922 7334

Please note: This table was correct at the time of printing but is subject to change from time to time. For the most up-to-date list, the reader is advised to consult the ARPANSA web site (www.arpansa.gov.au).

For after hours emergencies only, the police will provide the appropriate emergency contact number.

ARPANSA Radiation Protection Series Publications

ARPANSA has taken over responsibility for the administration of the former NHMRC Radiation Health Series of publications and for the codes developed under the *Environment Protection (Nuclear Codes) Act 1978*. The publications are being progressively reviewed and republished as part of the *Radiation Protection Series*. All of the Nuclear Codes have now been republished in the *Radiation Protection Series*.

All publications listed below are available in electronic format, and can be downloaded free of charge by visiting ARPANSA's website at www.arpansa.gov.au/Publications/codes/index.cfm.

Radiation Protection Series publications are available for purchase directly from ARPANSA. Further information can be obtained by telephoning ARPANSA on 1800 022 333 (freecall within Australia) or (03) 9433 2211.

- RPS 1 Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (republished 2002)
- RPS 2 Code of Practice for the Safe Transport of Radioactive Material (2008)
- RPS 2.1 Safety Guide for the Safe Transport of Radioactive Material (2008)
- RPS 3 Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz (2002)
- RPS 4 Recommendations for the Discharge of Patients Undergoing Treatment with Radioactive Substances (2002)
- RPS 5 Code of Practice and Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)
- RPS 6 National Directory for Radiation Protection – Edition 1.0 (2004)
- RPS 7 Recommendations for Intervention in Emergency Situations Involving Radiation Exposure (2004)
- RPS 8 Code of Practice for the Exposure of Humans to Ionizing Radiation for Medical Research Purposes (2005)
- RPS 9 Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)
- RPS 10 Code of Practice and Safety Guide for Radiation Protection in Dentistry (2005)
- RPS 11 Code of Practice for the Security of Radioactive Sources (2007)
- RPS 12 Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation (2006)
- RPS 13 Code of Practice and Safety Guide for Safe Use of Fixed Radiation Gauges (2007)
- RPS 14 Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (2008)
- RPS 14.1 Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology (2008)
- RPS 14.2 Safety Guide for Radiation Protection in Nuclear Medicine (2008)
- RPS 14.3 Safety Guide for Radiation Protection in Radiotherapy (2008)
- RPS 15 Safety Guide for Management of Naturally Occurring Radioactive Material (NORM) (2008)

- RPS 16 Safety Guide for the Predisposal Management of Radioactive Waste (2008)
- RPS 17 Code of Practice and Safety Guide for Radiation Protection in Veterinary Medicine (2009)
- RPS 18 Safety Guide for the Use of Radiation in Schools Part 1: Ionizing Radiation (2009)

Those publications from the NHMRC *Radiation Health Series* that are still current are:

- RHS 8 Code of nursing practice for staff exposed to ionizing radiation (1984)
- RHS 9 Code of practice for protection against ionizing radiation emitted from X-ray analysis equipment (1984)
- RHS 13 Code of practice for the disposal of radioactive wastes by the user (1985)
- RHS 14 Recommendations for minimising radiological hazards to patients (1985)
- RHS 15 Code of practice for the safe use of microwave diathermy units (1985)
- RHS 16 Code of practice for the safe use of short wave (radiofrequency) diathermy units (1985)
- RHS 18 Code of practice for the safe handling of corpses containing radioactive materials (1986)
- RHS 21 Revised statement on cabinet X-ray equipment for examination of letters, packages, baggage, freight and other articles for security, quality control and other purposes (1987)
- RHS 22 Statement on enclosed X-ray equipment for special applications (1987)
- RHS 24 Code of practice for the design and safe operation of non-medical irradiation facilities (1988)
- RHS 25 Recommendations for ionization chamber smoke detectors for commercial and industrial fire protection systems (1988)
- RHS 28 Code of practice for the safe use of sealed radioactive sources in bore-hole logging (1989)
- RHS 30 Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields (1989)
- RHS 31 Code of practice for the safe use of industrial radiography equipment (1989)
- RHS 34 Safety guidelines for magnetic resonance diagnostic facilities (1991)
- RHS 35 Code of practice for the near-surface disposal of radioactive waste in Australia (1992)
- RHS 36 Code of practice for the safe use of lasers in schools (1995)
- RHS 38 Recommended limits on radioactive contamination on surfaces in laboratories (1995)

Bibliography

- ARPANSA 2002, *Recommendations for Limiting Exposure to Ionizing Radiation (1995), and National Occupational Health and Safety Commission National Standard for Limiting Occupational Exposure to Ionizing Radiation*, Radiation Protection Series No. 1, republished 2002, ARPANSA, Yallambie.
- ARPANSA 2004, *National Directory for Radiation Protection, Edition 1.0 (2004)*, Radiation Protection Series No. 6, ARPANSA, Yallambie.
- ARPANSA 2005, *Code of Practice and Safety Guide for Radiation Protection in Dentistry (2005)*, Radiation Protection Series No. 10, ARPANSA, Yallambie.
- ARPANSA 2008. Australian Radiation Protection and Nuclear Safety Agency, *Code of Practice for the Safe Transport of Radioactive Material 2008 Edition*, Radiation Protection Series No. 2, ARPANSA, Yallambie.
- ARPANSA 2008. Australian Radiation Protection and Nuclear Safety Agency, *Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation*, Radiation Protection Series No. 14, ARPANSA, Yallambie.
- ARPANSA 2008. Australian Radiation Protection and Nuclear Safety Agency 2008, *Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology*, Radiation Protection Series No. 14.1, ARPANSA, Yallambie.
- ARPANSA 2008. Australian Radiation Protection and Nuclear Safety Agency 2008, *Safety Guide for Radiation Protection in Nuclear Medicine*, Radiation Protection Series No. 14.2, ARPANSA, Yallambie.
- ARPANSA 2008. Australian Radiation Protection and Nuclear Safety Agency 2008, *Safety Guide for Radiation Protection in Radiotherapy*, Radiation Protection Series No. 14.3, ARPANSA, Yallambie.
- AS 1992. Standards Australia. *Development, testing and implementation of information and safety symbols and symbolic signs*, AS 2342-1992.
- AS 1994. Standards Australia. *Safety signs for the occupational environment*, AS 1319-1994.
- AS/NZS 1997. Standards Australia. *Approval and test specification – Medical electric equipment – Particular requirements for safety – Diagnostic and therapeutic laser equipment*, AS/NZS 3200.2.22-1997.
- AS/NZS 1999. Standards Australia. *Medical electrical equipment – Particular requirements for safety – High voltage generators of diagnostic X-ray generators*, AS/NZS 3200.2.7-1999.
- AS/NZS 2004. Standards Australia. *Guide to the safe use of lasers in health care*, AS/NZS 4173-2004.
- International Commission on Radiological Protection 1991, *1990 Recommendations of the International Commission on Radiological Protection*, Oxford, Pergamon Press, ICRP Publication 60, Annals of the ICRP Vol. 21 No. 1-3.
- NHMRC 1982. *Code of practice for the safe use of ionizing radiation in veterinary radiology: Parts 1 and 2 (1982)*. Radiation Health Series No. 3.
- NHMRC 1982. *Code of practice for safe use of ionizing radiation in veterinary radiology: part 3-radiotherapy (1984)* Radiation Health Series No. 10.

Glossary

absorbed dose

the energy absorbed per unit mass by matter from ionizing radiation which impinges upon it.

Absorbed dose, D , is defined by the expression:

$$D = \frac{dE}{dm}$$

where dE is the mean energy imparted by ionizing radiation to matter of mass dm .

The unit of absorbed dose is joule per kilogram ($J\ kg^{-1}$), with the special name gray (Gy).

activity

the measure of quantity of radioactive materials, except when used in the term 'human activity'.

Activity, A , is a measure of the amount of a radioactive material given by:

$$A = \frac{dN}{dt}$$

where dN is the expectation value of the number of spontaneous nuclear transitions which take place in the time interval dt .

The unit of activity is s^{-1} with the special name becquerel (Bq).

ambient dose equivalent, $H^*(d)$

at a point in a radiation field, is the dose equivalent that would be produced by the corresponding expanded and aligned field, in the **ICRU** sphere at a depth, d , on the radius opposing the direction of the aligned field.

Unit: $J\ kg^{-1}$. The special name for the unit of ambient dose equivalent is sievert (Sv).

authorisation

a written permission granted by the relevant regulatory authority to perform specified practices. The form of an authorisation can include a licence, registration, or accreditation.

coefficient of variation, C

the ratio of the standard deviation to the mean value of a series of irradiation measurements calculated using the following equation:

$$C = \frac{S}{\bar{x}} = \frac{1}{\bar{x}} \left[\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1} \right]^{\frac{1}{2}}$$

where

x_i	=	i^{th} measurement
\bar{x}	=	mean value of measurements
S	=	estimated standard deviation
n	=	number of measurements.

contamination

the presence of a radioactive material on a surface in quantities in excess of $0.4\ Bq/cm^2$ for beta and gamma emitters and low toxicity alpha emitters, or $0.04\ Bq/cm^2$ for all other alpha emitters.

deterministic effect

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

detriment

a measure, or measures, of harm caused by exposure to radiation and usually taken to mean health detriment; it has no single definition, but can be taken to be an attribute or a collection of attributes which measure harm, such as attributable probability of death and reduction of life expectancy.

diagnostic radiology

the use of X-rays to diagnose disease, injury or provide imaging information for veterinary purposes.

directional dose equivalent, $H'(d, \Omega)$

at a point in a radiation field, is the dose equivalent that would be produced by the corresponding expanded field, in the ICRU sphere at a depth, d , on a radius in a specified direction, Ω .

Unit: $J\ kg^{-1}$. The special name for the unit of directional dose equivalent is sievert (Sv).

A depth $d=0.07\ mm$ is recommended for weakly penetrating radiation

dose

a generic term that may mean absorbed dose, equivalent dose or effective dose depending on context.

dose constraint

a prospective restriction on anticipated dose, primarily intended to be used to discard undesirable options in an optimisation calculation.

In occupational exposure, a dose constraint may be used to restrict the options considered in the design of the working environment for a particular category of employee.

In **public exposure**, a dose constraint may be used to restrict the exposure of the critical group from a particular source of radiation.

effective dose

a measure of dose which takes into account both the type of radiation involved and the radiological sensitivities of the organs and tissues irradiated.

Effective dose, E , is the sum of weighted equivalent doses in all organs and tissues of the body. It is given by the expression:

$$E = \sum_T w_T H_T$$

where H_T is the equivalent dose in organ or tissue T and w_T is the tissue weighting factor for that organ or tissue.

The unit of effective dose is $J\ kg^{-1}$, with the special name sievert (Sv).

equivalent dose

a measure of dose in organs and tissues which takes into account the type of radiation involved.

Equivalent dose, H , is a weighted dose in an organ or tissue, with the radiation weighting factor(s) determined by the type and energy of the radiation to which the organ or tissue is exposed. The equivalent dose H_T in organ or tissue T is given by the expression:

$$H_T = \sum_R w_R D_{T,R}$$

where $D_{T,R}$ is the absorbed dose averaged over the organ or tissue T due to radiation R and
 w_R is the radiation weighting factor for that radiation.

The unit of equivalent dose is the same as for absorbed dose, $J\ kg^{-1}$, with the special name sievert (Sv).

gamma radiation

electromagnetic radiation emitted spontaneously from the nucleus of an atom in the process of a nuclear transition.

half-life

in relation to radioactive decay, the time required for the quantity of a radionuclide to decrease to one half of its initial value.

handler

a person who voluntarily, willingly and knowingly assists or helps in the handling, care, support or comfort of animals undergoing a diagnostic or therapeutic radiation procedure.

ICRP

the International Commission on Radiological Protection. It is an independent organisation that provides general guidance on radiation protection. The recommendations of the ICRP are not legally binding, but are generally followed by countries framing national regulatory requirements.

ICRU

the International Commission on Radiation Units and Measurement.

interventional radiology

procedures comprising guided therapeutic and diagnostic interventions, by percutaneous or other access, usually performed under local anaesthesia or sedation, with fluoroscopic or computed tomographic imaging used to localise, in conjunction with a surgical procedure, the lesion/treatment site, monitor the surgical procedure, or control and document the therapy or diagnosis.

ionizing radiation

electromagnetic or particulate radiation capable of producing ions directly or indirectly, but does not include electromagnetic radiation of a wavelength greater than 100 nanometres.

irradiating apparatus

any apparatus capable of producing ionizing radiation of any prescribed type, or capable of accelerating atomic particles under any prescribed conditions.

kerma, K

the quotient of dE_{tr} by dm , where dE_{tr} is the sum of the initial kinetic energies of all the charged particles liberated by uncharged particles in a mass dm of material, thus

$$K = \frac{dE_{tr}}{dm}$$

Unit: $J\ kg^{-1}$. The special name for the unit of kerma is gray (Gy).

laser

acronym for Light Amplification by Stimulated Emission of Radiation. Any device that can be made to produce or amplify electromagnetic radiation in the wavelength range from 100 nanometres to 1 millimetre by the process of controlled stimulated emission.

National Directory for Radiation Protection

the *National Directory for Radiation Protection*. Radiation Protection Series No. 6.

NHMRC

the National Health and Medical Research Council. Its principal function is to advise the Australian community on matters relating to the achievement and maintenance of high standards of individual and public health through appropriate legislation, administration and practices, and to encourage health and medical research to achieve those standards.

nuclear medicine

the use of unsealed radioactive sources for diagnostic imaging, physiological testing and therapy.

occupational exposure

exposure of a person to radiation which occurs in the course of that person's work and which is not excluded exposure²⁹.

operator

any natural person who is authorised by the relevant regulatory authority to administer radiation to an animal for radiology, nuclear medicine or radiotherapy.

personal radiation monitoring device

a device designed to be worn by a person to monitor the radiation dose received by the person.

practice

a type of human activity; in a radiological context, a human activity which may result in exposure to ionizing radiation and to which a system of radiation protection applies.

²⁹ Excluded exposure means the component of exposure that arises from natural background radiation.

public exposure

exposure of a person, or persons, to radiation which is neither occupational nor medical exposure.

qualified expert

a person who:

- (a) is qualified in the application of the physics of therapeutic or diagnostic uses of ionizing radiation; and
- (b) has been recognised by the relevant regulatory authority as being able to perform the dosimetric calculations, radiation measurements and monitoring relevant to the person's area of expertise³⁰.

radiation

electromagnetic waves or quanta, and atomic or sub-atomic particles, propagated through space or through a material medium.

radiation incident

any unintended or ill-advised event when using ionizing radiation apparatus, specified types of non-ionizing radiation apparatus or radioactive substances, which results in, or has the potential to result in, an exposure to radiation to any person or the environment, outside the range of that normally expected for a particular practice, including events resulting from operator error, equipment failure, or the failure of management systems that warranted investigation.

radiation-producing equipment

any equipment that produces ionizing radiation when energised.

radioactive material

material which spontaneously emits ionizing radiation as a consequence of radioactive decay.

radioactive source

any quantity of radioactive material which is intended for use as a source of ionizing radiation.

radiotherapy

the therapeutic use of ionizing radiation from radiation-producing equipment and sealed radioactive sources to treat disease.

relevant regulatory authority

the radiation protection authority or authorities designated, or otherwise recognised, for regulatory purposes in connection with protection and safety relating to veterinary applications of ionizing radiation. A list of relevant regulatory authorities in Australia is provided at page 83.

reportable radiation incident

a radiation incident as defined in Schedule 13 of the *National Directory for Radiation Protection*.

³⁰ Competency requirements for a qualified expert will be listed in future editions of the *National Directory for Radiation Protection*.

Responsible Person

in relation to any radioactive source, radiation-producing equipment, prescribed radiation facility or premises on which radioactive sources are stored or used means the legal person³¹:

- (a) having overall management responsibility including responsibility for the security and maintenance of the source, radiation-producing equipment, facility or premises;
- (b) having overall control over who may use the source, radiation-producing equipment, facility or premises; and
- (c) in whose name the source, radiation-producing equipment, facility or premises would be registered if this is required.

RPS1

the *Recommendations for limiting exposure to ionizing radiation (1995) (NOHSC guidance note)* and the *National standard for limiting occupational exposure to ionizing radiation*. Radiation Protection Series No. 1.

sealed radioactive source

a radioactive substance bonded within metals or sealed in a capsule or other container in such a way as to-

- (a) minimise the possibility of escape or dispersion of the radioactive substance; and
- (b) allow the emission of ionizing radiation for use as required.

source assembly

the component into which the radiation source(s) are permanently fixed. The source assembly may be movable or may itself be permanently fixed.

supplier

any legal person to whom a registrant or licensee delegates duties, totally or partially, in relation to the design, manufacture, production or construction of a source. (An importer of a source is considered a supplier of the source.)

Transport Code, the

the most recent edition of the *Code of Practice for the Safe Transport of Radioactive Material*. Radiation Protection Series No. 2.

unsealed radioactive source

a radioactive source that is not a sealed radioactive source.

veterinary surgeon

the practitioner responsible for the overall conduct of the procedure involving the exposure of the animal to ionizing radiation.

³¹ A legal person can be a natural person, a body corporate, a partnership or any other entity recognised as a 'legal person' by the legislation in the jurisdiction.

Contributors to Drafting and Review

The initial draft was prepared by Mr Ray de Groot, Consultant Physicist.

The following Working Group was formed to develop and finalise the draft:

Working Group

Mr Ray de Groot	Consultant Physicist (Convenor)
Dr Graeme Allan	The University of Sydney
Mr Keith Baldry	Director, Radiation Protection Division, Environment Protection Authority, South Australia
Mr Simon Critchley	Director, Radiation Health Unit, Department of Health, Queensland
Mr Keith Dessent	Standards Development & Committee Support Section, ARPANSA
Mr Alan Melbourne	Manager, Standards Development & Committee Support Section, ARPANSA
Ms Zoe O'Donnell	Radiation Health Branch, Department of Health, Western Australia

Index

- A**
- access control.....19, 65, 66
 accountability.....10, 46
 activity..... 10, 14, 34-36, 87, 90
 ALARA principle..... 5, 7, 9, 18, 43, 55, 65, 79
 animal restraint 18, 28, 50, 67
 approval8-10, 82
 authorisation..... 6, 9-10, 12, 15, 19, 23, 27, 32, 35-37, 46, 87, 90
- B**
- brachytherapy..... 12-14, 16
- C**
- calibration..... 12-13, 25, 33, 47, 55, 64
 carer 8
 Certificate of Measurement..... 60
 compliance 8, 11, 15, 19, 37
 contamination...14, 28-29, 45, 59, 70-72, 87
- D**
- death of an animal 14, 31
 dental equipment.....12, 24, 49, 58
 deterministic effect 78-79
 detriment 7-8, 88
 diagnostic radiology.....6, 20, 43, 88
 disposal . 10, 14, 19, 27-28, 34, 36, 46, 48
 dose
absorbed..... 87-89
constraint..... 10, 18, 44, 49, 54, 88
effective 9-10, 19, 44, 54, 79, 88
equivalent..... 79, 88-89
limits..... 7, 9, 44-45, 47, 49, 65, 79
rate 24, 60, 64-65, 79, 87-89
 dosimetry 18, 27
- E**
- emergency 14, 18, 47, 55, 83
 epidemiological study..... 78
 equine yearling sales..... 6, 15
 excretion..... 59
 exposure5, 7-9, 11-12, 14-16, 18, 23, 25-26, 32-33, 37, 41, 43-47, 50-51, 53, 55-56, 69, 74, 78-82, 88, 90-92
medical..... 91
occupational... 5, 7, 9-11, 13, 18, 44, 47, 51, 53, 55, 69, 78-79, 88, 90, 92
public..... 7, 9-10, 13, 18-19, 44, 55, 59, 78-79, 88, 91
 eye 60-61, 79, 81
- F**
- fault 13, 17-18
 fluoroscopy.....12, 23, 52, 59, 89
- G**
- gamma radiation 32, 47, 64, 80, 89
 gold-198 35
- H**
- half-life..... 60, 89
 hand 30, 50, 58, 67, 71, 79
 handler..... 14, 89
 hazard 5, 11, 18-21, 23, 27, 29, 32, 35, 45-46, 51, 55, 57, 63, 65-66, 81-82
 health effect 16, 19, 51, 61-62, 78, 88
- I**
- identification 15, 33, 47
 implantation 35
 inspection 48, 53
 instructions..11, 14, 19-20, 28, 30, 34-35, 44, 48, 55, 70, 72
 International Atomic Energy Agency (IAEA)..... i, 79
 International Commission on Radiological Protection (ICRP) i, 7, 79, 86, 89
 interventional radiology..... 15, 89
 iodine-131..... 29
 isolation 18
- J**
- justification..... 7-8, 79
- K**
- kerma 22-26, 32, 64, 90
- L**
- label..... 21, 25, 41, 75
 lasers 5-6, 12, 37, 41, 81-82, 90
 licence 18, 81, 87
 light beam collimator (LBC) 16, 22, 25-26, 57
 limitation 9, 79
 local rules..... 48
- M**
- maintenance 13, 43, 46, 90, 92
 monitoring..... 9, 30, 46-47, 49, 55-56, 91
- N**
- National Health and Medical Research Council (NHMRC)..... i, 5, 84-86, 90
 National Occupational Health & Safety Commission (NOHSC) 80, 92
 national standards.... i, 64, 79-80, 84, 86
 nuclear medicine 5-6, 12, 15, 27-28, 43-45, 47-48, 59, 90

O

observation 18, 33
operator 5, 8, 13, 15-18, 20-21, 23, 25-26,
29, 34, 37, 45, 90-91
optimisation 7-9, 79, 88

P

personal monitoring device 9, 34, 41,
53-55
personal protective equipment 15-16,
18, 20, 37, 51, 55, 58-59
personal radiation monitoring 15, 18,
41, 53-55, 90
post mortem examination 31
practice i, 5-8, 10-11, 18-19, 27, 37,
43-44, 46-48, 56, 61, 69, 74, 87, 90-91
pregnancy 10, 28, 51, 59, 79
protocol 12, 15, 18, 28, 30, 46

Q

qualified expert 12-13, 33, 91
Quality Assurance Program 56
quality control 27, 56

R

Radiation Health Committee (RHC) . i-ii,
79
radiation incident 5, 10-11, 17-19, 41,
46-47, 54, 56, 78, 91
Radiation Management Plan i-ii, 5, 8,
11, 15-19, 44, 46-47, 54-55
radiation protection principles 5, 7, 80
Radiation Protection Series (RPS) i-ii,
5, 39, 80, 84, 86, 90, 92
*Code of Practice for the Safe Transport
of Radioactive Material
(RPS No. 2) 47, 63, 84, 86, 92*
*National Directory for Radiation
Protection (RPS No. 6) 5, 9, 11, 19,
84, 86, 90-91*
*Recommendations for limiting
exposure to ionizing radiation
(1995) (NOHSC guidance note)
and the National standard for
limiting occupational exposure
to ionizing radiation.
(RPS No. 1) 7, 9-10, 19-20, 44,
55, 65, 84, 86, 92*
Radiation Protection Standards ... 44-45,
78
Radiation Safety Officer (RSO) ii, 41,
46, 55
Radiation Source Register 10
radiation-producing equipment 9-13,
15-17, 91, 92
radioactive
*material i, 9-10, 12-14, 16-19, 27-32,
34-35, 46-48, 53, 59, 61, 64-66, 87,
91-92*

waste 8-9, 19, 27, 29-31, 48
waste management 8, 19
radiography 12, 16, 20, 22-23, 26, 29,
32, 45-46, 49-51, 53, 57-58, 67, 69
radiopharmaceutical 10, 14, 18, 27
radiotherapy 5-6, 12-13, 15-16, 18, 32,
35, 43, 45, 59, 90-91
receipt 10, 28, 34
records 9, 13, 17, 28, 41, 46-48, 53,
55-56, 59, 73
register 11, 33, 87
regulatory authority 6, 9-10, 12-13, 15,
18-19, 23, 27, 32, 35-37, 43, 46-48,
53-54, 56, 81, 83, 87, 90-91
regulatory requirements 5, 89
repairs and maintenance 13, 36, 46,
53, 64, 73
reportable radiation incident 10, 91
Responsible Person i, 5, 8-15, 17, 19,
36, 41, 46-49, 51, 53-54, 56, 65-66, 82,
92
risk 5, 8, 14, 23, 31, 41, 45-46, 50, 57,
70, 78-79

S

safety procedures 18-19, 43-44, 47
screening 6, 15
security 19, 92
shielding 9, 11-12, 16, 18-21, 25,
28-30, 34-36, 48, 52, 56-59, 62-63, 65
shock 70, 82
skin 59, 61, 78, 79, 81
source
assembly 21, 92
containment 61, 65
sealed 10, 14, 32-35, 91, 92
*unsealed 10, 14, 18, 27-28, 45, 65,
90, 92*
spectrum 81
staff ... 13, 18, 26, 37, 44, 46-48, 51, 55, 69
sterilisation 61
storage 14, 18-19, 23, 26, 28, 30, 33,
36, 41, 46, 48, 61-63, 65-66, 70
strontium-90 35-36, 41, 60-63
supplier 26, 74, 92
surface 22-23, 26, 32, 35, 60-62, 65,
70, 72-73, 87
survey meter 30, 34, 41, 47, 55, 64

T

technetium-99m 28, 29
temperature 69, 70-73
testing 55, 73, 82
training 11, 18, 23, 27, 32, 37
transfer 46
transport 19, 36, 46-47, 63, 92
treatment ... 5, 13-18, 29-35, 59-61, 63, 89

U

ultraviolet radiation.....81

W

warning notices..... 11, 12, 28, 33-34,
36-37, 51, 57, 63, 75
working procedures 44, 46, 49, 55

X

x-ray tube..... 16, 20-21, 23-26, 32-33,
45, 50-51, 58, 66

Y

yttrium-90 60