



**Australian Government**

**Australian Radiation Protection and Nuclear Safety Agency**

**CODE OF PRACTICE**

Safe Use of Radiation in  
Veterinary Science

Radiation Protection Series Publication No. ??

Public Consultation Version: February 2005

## Radiation Protection Series

The *Radiation Protection Series* is published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to promote practices that 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 prescriptive 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 prescriptive 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-prescriptive 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, prescriptive 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.



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This publication was approved by the Radiation Health Committee on XX XXXXXXXX 200X, and the Radiation Health & Safety Advisory Council at its meeting on XX XXXXXXXX 200X, advised the CEO to adopt the Code of Practice.

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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 Chief Executive Officer of ARPANSA in [month yyyy]

# **Foreword**

Foreword Text

[signature]

John Loy  
CEO of ARPANSA



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# 1. Introduction

## 1.1 CITATION

This Code of Practice may be cited as the *Code of Practice for Radiation Protection in Veterinary Science (2005)*.

## 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 science. 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. This Code of Practice replaces two Codes 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 the guidance provided in these two Codes, this Code of Practice has been expanded to give guidance on veterinary nuclear medicine and the use of lasers in veterinary science.

## 1.3 PURPOSE

This Code details the requirements that must be followed in the use of radiation in veterinary science. It provides a supplement to the radiation control legislation enacted in Australia and implemented by the appropriate regulatory authorities (see Annex 7). This Code is not a substitute for this legislation but should be studied in conjunction with it. Advice on this legislation and on any aspects of the implementation of this Code should be sought from these authorities.

## 1.4 SCOPE

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

The Code lays down detailed requirements for the following protective measures:

- (a) allocation of responsibility for all safety procedures and radiation surveillance;
- (b) provision of appropriate premises and installations;
- (c) provision of appropriate radiation and ancillary equipment; and
- (d) provision of appropriate maintenance and safety checking of equipment.

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

52  
53 This Code details the requirements that must be followed in the use of  
54 radiation in veterinary science. Nevertheless, the implementation of these  
55 requirements must be achieved using sound judgement in specific situations  
56 and, consequently, establishments must draw up their own detailed working  
57 procedures based on relevant legislation and this Code, and that they issue  
58 appropriate instructions to all workers who may be exposed to radiation in the  
59 course of their duties.

## 61 **1.5 STRUCTURE**

62  
63 The Code is structured in six sections:

64		
65	Section 1	Introduction
66	Section 2	Responsibilities and Radiation Surveillance
67	Section 3	Diagnostic Radiology
68	Section 4	Radiotherapy
69	Section 5	Diagnostic and Therapeutic Nuclear Medicine
70	Section 6	Lasers

71  
72 Schedules to the Code form integral parts of the Code requirements. Schedule  
73 1 specifies the dose limits for occupational exposure and for members of the  
74 public.

75  
76 Annexes to the Code provide additional background information and do not  
77 include mandatory requirements.

78		
79	Annex 1	provides information on Health Effects of Ionizing
80		Radiation and Standards for Control of Exposure.
81	Annex 2	describes ancillary equipment for radiography.
82	Annex 3	provides a guide to manual processing of radiographs.
83	Annex 4	gives examples of radiation warning labels and notices.
84	Annex 5	provides advice on strontium-90 applicators.
85	Annex 6	provides information on lasers and laser safety.
86	Annex 7	lists the relevant Radiation Protection Authorities.
87	Annex 8	lists other publications in the Radiation Protection Series.

88  
89 The Code also includes a Glossary of Terms and a section providing  
90 References. Terms that are described in the Glossary appear in **bold type** on  
91 their first occurrence in the text.

## 93 **1.6 INTERPRETATION**

94  
95 The words 'must' and 'should', where used in this Code have specialised  
96 meanings. 'Must' indicates that the particular requirement is mandatory.  
97 'Should' indicates a requirement that is to be applied as far as practicable, in  
98 the interest of reducing radiation risks.

99 **1.7 CATEGORIES OF EXPOSED PERSONS IN VETERINARY**  
100 **SCIENCE**

101  
102 Radiation Protection Standards are considered for two categories of exposed  
103 persons. These are:

- 104 (a) persons occupationally exposed to radiation, i.e. all exposure of  
105 persons to ionizing radiations which occurs at work; and  
106 (b) members of the public, i.e. all exposures of persons that are neither  
107 occupational nor medical.  
108

109 Persons occupationally exposed to radiation include all members of a  
110 department or practice, including veterinary students, temporary or visiting  
111 staff whose duties are likely to require their presence during radiographic,  
112 radiotherapeutic or nuclear medicine procedures.  
113

114 Members of the public include all other persons, e.g. owners of animals,  
115 observers, and persons living adjacent to the premises where radiation is used.  
116

117 **1.8 RISK OF RADIATION INJURY IN VETERINARY SCIENCE**

118  
119 If the provisions of this Code are applied carefully and consistently, the dose  
120 limits will not be exceeded and the risk of radiation injury will be slight.  
121 However, if the dose limits laid down in the Radiation Protection Standards  
122 are exceeded by a large factor in a single exposure or in a number of exposures  
123 over a short period of time, or are exceeded over a long period, injury may  
124 result. Attention is drawn to the manner in which the dose limits may be  
125 exceeded in relation to the veterinary practice.  
126

127 In radiography, the principal hazard arises from the possibility of exposure to  
128 the primary X-ray beam. Scattered radiation and radiation leaking from the  
129 X-ray tube assembly, which are always present during an exposure, may also  
130 contribute further significant doses.  
131

132 In radiotherapy, the radiation dose delivered to the patient is very much  
133 greater than in diagnostic procedures and thus the hazard may be very much  
134 greater to the operator.  
135

136 In nuclear medicine or radiotherapy using unsealed radioactive material (i.e.  
137 liquid solutions, gelatine capsules, gases or aerosols), there is the additional  
138 hazard of radioactive **contamination** that leads to potential inhalation or  
139 ingestion risks.  
140

141 **2. Responsibilities and Radiation**  
142 **Surveillance**  
143

144 **2.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON**  
145

146 2.1.1 The **Responsible Person** must be familiar with all requirements of  
147 the **relevant regulatory authority** including registration, licensing,  
148 controlled or supervised radiation areas, monitoring, recording of  
149 personal doses, reporting, surveying, maintenance and quality control  
150 checks.

151  
152 2.1.2 The Responsible Person must ensure that the transport of radioactive  
153 material complies with the *Code of Practice for the Safe Transport of*  
154 *Radioactive Material (2001)*;

155  
156 2.1.3 The Responsible Person must ensure that radiation doses:

157 (a) are kept as low as reasonably achievable; and

158 (b) do not exceed the appropriate dose limits specified in  
159 Schedule 1<sup>1</sup>.

160  
161 2.1.4 The Responsible Person must appoint a Radiation Safety Officer (who  
162 may also be the Responsible Person) who has sufficient professional  
163 and/or technical training to:

164 (a) supervise radiation protection in order to minimise personal  
165 radiation doses;

166 (b) advise staff on safe working practices in accordance with all  
167 legislation and codes of practice;

168 (c) consult and liaise with the relevant regulatory authority;

169 (d) ensure that all relevant regulatory matters are duly processed;

170 (e) monitor and survey controlled or supervised areas, equipment  
171 and operations as necessary and upon request;

172 (f) ensure that suitable personal and other monitoring devices are  
173 provided where required, kept in good working order, properly  
174 used, and calibrated;

175 (g) arrange for records to be kept of **effective doses** where  
176 determined for individuals;

177 (h) arrange for any required medical services to be provided and for  
178 records to be kept;

179 (i) record and report to the Responsible Person and the appropriate  
180 authorities any unsafe practices or **incidents**;

---

<sup>1</sup> Additional information on health effects and Standards for control of exposure to ionising radiation is provided in Annex 1.

- 183 (j) prepare local rules for the handling of any foreseeable incidents  
 184 and emergencies, assemble an emergency kit and take charge of  
 185 such situations;
- 186 (k) maintain current records of all stocks and locations of  
 187 radioactive materials and **irradiating apparatus**;
- 188 (l) arrange for any records required by Sub-clause (k) to be kept for  
 189 a period specified by the appropriate authority;
- 190 (m) arrange for the safe storage of radioactive materials and for the  
 191 safe disposal of any radioactive waste;
- 192 (n) provide advice, instruction and local rules on radiation safety in  
 193 an easily understandable form and at an adequate level for  
 194 persons involved with ionizing radiation;
- 195 (o) perform any other tasks that may be necessary to maintain a  
 196 high standard of radiation safety in the establishment; and
- 197 (p) determine which staff are to be designated 'persons  
 198 occupationally exposed to radiation' under Clause 1.7.  
 199
- 200 2.1.5 The Responsible Person must ensure that the Radiation Safety Officer  
 201 has the authoritative standing to implement this Code.  
 202
- 203 2.1.6 The Responsible Person must determine the work procedures that are  
 204 necessary to enable the implementation of this Code.  
 205
- 206 2.1.7 The Responsible Person must provide all the facilities and equipment  
 207 that are necessary to enable the implementation of this Code.  
 208
- 209 2.1.8 The Responsible Person must support all the requirements for the  
 210 implementation of the Radiation Safety Officer's responsibilities.  
 211
- 212 **2.2 RADIATION SURVEYS**  
 213
- 214 2.2.1 The Responsible Person must ensure that plans for buildings that are  
 215 to incorporate radiographic, radiotherapeutic or nuclear medicine  
 216 facilities including details of shielding and/or other safety facilities are  
 217 submitted to the relevant regulatory authority before commissioning.  
 218
- 219 2.2.2 The Responsible Person, in consultation with the relevant regulatory  
 220 authority, must ensure that appropriate radiation safety assessments  
 221 are made by an appropriately qualified person for the following  
 222 circumstances:
- 223 (a) before the installation is put into routine use;
- 224 (b) where the installation or working procedures are to be  
 225 modified<sup>2</sup>;

---

<sup>2</sup> 'Modified' means a change in the amount of radiation, the manner of its use or a change in the X-ray equipment or its location. Such modifications may mean the original protection is no longer adequate.

- 226 (c) where personal monitoring indicates that the doses received by  
227 any person exceed, or are likely to exceed the appropriate dose  
228 limits or are higher than normal for no obvious reason, or are  
229 higher than average doses received in similar departments and  
230 practices;
- 231 (d) where changes are to be made in the immediate environs that  
232 may result in an increase of occupancy<sup>3</sup>.
- 233 (e) where an increase in work load in the department or practice is  
234 anticipated;
- 235 (f) whenever any servicing is carried out on the X-ray tube  
236 assembly; or
- 237 (g) the X-ray high voltage generator is replaced or otherwise  
238 significantly modified.
- 239
- 240 2.2.3 The Responsible Person must notify the relevant regulatory authority  
241 if a radiation safety assessment indicates that any person has or may  
242 have received doses in excess of the relevant effective dose limits or  
243 relevant dose constraints established.  
244

---

<sup>3</sup> An example would be a store or waiting area becoming an office.

245 **3. Diagnostic Radiology**

246

247 **3.1 GENERAL REQUIREMENTS**

248

249 3.1.1 During radiographic or fluoroscopic examinations, the Responsible  
250 Person must ensure that:

251 (a) each examination is only carried out by appropriately trained  
252 and qualified personnel who are licensed as required by the  
253 relevant regulatory authority;

254 (b) only persons who are essential to a procedure are present;

255 (c) each person present is properly instructed to enable them to  
256 understand their part in the proposed procedure;

257 (d) where practicable, each person present is positioned behind a  
258 protective screen; and

259 (e) any person who is unable to position themselves behind a  
260 protective screen:

261 (i) wears a protective apron; and

262 (ii) remains as far as practicable from the primary X-ray  
263 beam, the animal and the X-ray tube assembly.

264

265 **3.2 RADIOGRAPHY PROCEDURES**

266

267 3.2.1 The Responsible Person must ensure that radiography is only  
268 undertaken if:

269 (a) there is a clear indication for the procedure; and

270 (b) it can be done without undue radiation hazard.

271

272 3.2.2 The veterinary surgeon in charge of a radiography procedure must  
273 ensure that no part of any person, even if shielded by protective  
274 clothing, is exposed to the primary X-ray beam.

275

276 **3.3 FLUOROSCOPY PROCEDURES**

277

278 3.3.1 The Responsible Person must ensure that specific approval is obtained  
279 from the relevant regulatory authority before fluoroscopy<sup>4</sup> procedures  
280 are carried out.

281

282 3.3.2 The Responsible Person must ensure that each operator of  
283 fluoroscopic imaging equipment:

---

<sup>4</sup> 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 because of the additional risks it should not be used as the primary diagnostic tool or as an alternative to radiography. Fluoroscopy is indicated only in circumstances in which it is essential to study movement or for complex surgical techniques. In this case, a fluoroscopy unit with image storage facilities should be considered to further minimise radiation dose levels.

- 284 (a) has adequate knowledge and training to use the equipment; and  
285 (b) has obtained special approval from the relevant regulatory  
286 authority to use fluoroscopy equipment.  
287  
288 3.3.3 The Responsible Person must ensure that, when indications are  
289 sufficiently definite for fluoroscopy, fluoroscopy is only carried out:  
290 (a) if suitable equipment is available;  
291 (b) by veterinary or medical personnel trained and experienced in  
292 the technique; and  
293 (c) by persons who hold a relevant licence or other approval issued  
294 by the relevant regulatory authority.  
295  
296 3.3.4 The veterinary surgeon in charge of a fluoroscopy procedure must, in  
297 the case of a fluoroscopic examination, ensure that:  
298 (a) no part of any person is exposed to the primary beam unless it is  
299 adequately shielded by protective clothing (see Clauses 3.13.5  
300 and 3.13.6); and  
301 (b) fluoroscopy is only carried out in accordance with the  
302 requirements of Clauses 3.3.1 to 3.3.3.  
303

### 304 **3.4 REDUCTION OF RADIATION HAZARDS**

- 305  
306 3.4.1 The Responsible Person must ensure that:  
307 (a) the fastest film and film-intensifying screen combination  
308 compatible with acceptable image quality is used;  
309 (b) cassettes and intensifying screens are cleaned and maintained;  
310 (c) all assistants receive clear instructions on the procedure to be  
311 undertaken and understand their part in it; and  
312 (d) appropriate film processing facilities are available and are used  
313 correctly (see Annex 3);  
314 (e) routine working procedures for radiography are developed and  
315 these procedures are:  
316 (i) appropriate to the type of work carried out in the  
317 establishment;  
318 (ii) followed by each person carrying out and assisting with  
319 radiography; and  
320 (iii) posted in the X-ray areas.  
321  
322 3.4.2 The veterinary surgeon in charge of a radiology procedure must ensure  
323 that:  
324 (a) cassette holders are used whenever a cassette cannot be  
325 supported on a table, on the ground or on another support;  
326 (b) all practical precautions are taken to avoid unnecessary  
327 repetition of radiographs;

- 328 (c) the primary beam is restricted to the area to be examined by  
329 means of the collimator;
- 330 (d) all assistants:
- 331 (i) remain behind the protective screens; or
- 332 (ii) where there is no screen, wear protective clothing and  
333 position themselves as far as practicable from the X-ray  
334 tube assembly, the animal and the path of the primary  
335 X-ray beam;
- 336 (e) the exposure is not made until the animal is properly restrained  
337 and positioned in accordance with Section 3.7 below;
- 338 (f) any person supporting a cassette holder remains as far as  
339 practicable, and in any case at least 1 metre, from the edge of the  
340 primary beam;
- 341 (g) no person holds the X-ray tube assembly or the cassette during  
342 radiography;
- 343 (h) the X-ray tube assembly is rigidly supported by a mechanical  
344 holder, stand or wall mounted arm that:
- 345 (i) provides adequate stability; and
- 346 (ii) does not allow movement blurring of the radiograph.  
347

### 348 **3.5 RADIOLOGY IN DEFINED X-RAY ROOMS OR AREAS**

349

350 3.5.1 The Responsible Person must ensure that a defined X-ray room or area  
351 for veterinary radiology consists of or contains:

- 352 (a) a space of sufficient dimensions to allow full freedom of  
353 movement for the X-ray machine and its associated equipment,  
354 the examination table and for the persons involved in the  
355 procedures to take full advantage of distance;
- 356 (b) radiation shielding provisions for persons within and outside the  
357 room area (see Sub-clause 3.4.2(d));
- 358 (c) a means of restricting access to the room or area;
- 359 (d) X-ray warning signs at all entrances (see Annex 4);
- 360 (e) facilities for positioning and immobilising the animal;
- 361 (f) an X-ray machine that satisfies the requirements of Clause 3.8.5;  
362 and
- 363 (g) an X-ray machine that satisfies the relevant requirements of  
364 Clauses 0, 3.10, 3.11 or 3.12 as appropriate.  
365

366 3.5.2 The Responsible Person must ensure that all small animal radiography  
367 is carried out in a defined X-ray room or area.  
368

369 3.5.3 The Responsible Person must ensure that all shielding requirements  
370 for defined X-ray rooms or areas<sup>5</sup> meet the requirements of the  
371 relevant regulatory authority.  
372

### 373 **3.6 RADIOGRAPHY OUTSIDE DEFINED X-RAY ROOMS OR AREAS**

374  
375 3.6.1 Radiography of animals outside defined X-ray rooms or areas (in other  
376 parts of the premises, or on visits to farms, stables or kennels) is likely  
377 to add to the radiation risks for the following reasons:

- 378 (a) The usual ancillary and protective equipment may not be  
379 available.
- 380 (b) It is likely to be more difficult to immobilise the animal.
- 381 (c) The persons available to assist may be untrained and/or  
382 unaware of the hazards of radiation.
- 383 (d) It is likely to be more difficult to prevent the presence of  
384 unauthorised persons during radiography.
- 385 (e) There is a greater risk of irradiating persons in nearby areas.
- 386 (f) The light beam collimator may be ineffective (see Sub-clause  
387 3.9.1(c)).  
388

389 3.6.2 When radiography is carried out outside defined X-ray rooms or areas,  
390 the Responsible Person must ensure that:

- 391 (a) the necessary equipment, such as cassette holders, is available;
- 392 (b) lead backed cassettes or cassette holders are used;
- 393 (c) sufficient protective clothing is available for all persons taking  
394 part;
- 395 (d) the nature of the procedure and the precautions to be observed  
396 are carefully explained to the assistants before the radiographic  
397 exposures are made;
- 398 (e) adequate supports for the X-ray tube assembly and cassettes are  
399 provided;
- 400 (f) means are provided to achieve the correct alignment of the X-ray  
401 beam to the cassette and to ensure that the X-ray beam is  
402 collimated to an area equal to or less than the cassette (see  
403 Sub-clause 3.9.1(b)).  
404

405 3.6.3 When radiography is carried out outside defined X-ray rooms or areas,  
406 the veterinary surgeon in charge of a radiology procedure must ensure  
407 that:

- 408 (a) All safety equipment provided by the Responsible Person is  
409 used;

---

<sup>5</sup> The need for structural shielding can 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. In such circumstances, 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.

- 410 (b) the number of assistants is kept to the minimum necessary for  
411 the procedure;
- 412 (c) the nature of the procedure and the precautions to be observed  
413 are carefully explained to the assistants before the radiographic  
414 exposures are made;
- 415 (d) adequate precautions are taken to prohibit the access of  
416 unauthorised persons to the area during radiography<sup>6</sup>;
- 417 (e) the dose to members of the public<sup>7</sup> is minimised and does not  
418 exceed regulatory limits;
- 419 (f) adequate supports for the X-ray tube assembly and cassettes are  
420 used;
- 421 (g) no person holds X-ray tube assembly and cassettes directly; and
- 422 (h) the X-ray beam is correctly alignment to the cassette; and
- 423 (i) the X-ray beam is collimated to an area equal to or less than the  
424 cassette.  
425

### 426 **3.7 RESTRAINT OF ANIMALS**

427  
428 3.7.1 The animal must not be held for radiography unless for clinical  
429 reasons other means of immobilisation<sup>8</sup> are not practicable.

430  
431 3.7.2 When, in exceptional circumstances, manual restraint is necessary, the  
432 following procedures must be adopted:

- 433 (a) The animal must be restrained by the minimum number of  
434 persons necessary;
- 435 (b) All persons must position themselves as far as practicable from  
436 the path of the primary X-ray beam, the animal and the X-ray  
437 tube housing;
- 438 (c) No part of any person must be in the direct X-ray beam<sup>9</sup>;
- 439 (d) Each person holding the animal must wear protective gloves and  
440 an apron;
- 441 (e) Persons not normally exposed occupationally to ionizing  
442 radiation (for instance the owners of the animal) may be asked  
443 to hold the animal, provided that any reduction in control that  
444 results will not significantly increase the radiation hazard of the  
445 procedure.

---

<sup>6</sup> For example, by display of warning signs - see Annex IV.

<sup>7</sup> For example, assistants, persons either passing by or located in adjoining rooms or areas.

<sup>8</sup> Immobilisation of animals should be achieved by one or more of mechanical means, tranquillisation or anaesthesia. These methods will eliminate or reduce the radiation hazard from manual restraint and assist in the reduction of image blurring due to movement. Advice on mechanical restraints is given in Annex 2.

<sup>9</sup> 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.

- 446 (f) Persons under the age of 18 years must not hold animals during  
447 radiography and a notice to this effect must be displayed  
448 prominently in the X-ray area.
- 449 (g) Pregnant women must not hold animals during radiography<sup>10</sup>  
450 and a notice to this effect must be displayed prominently in the  
451 X-ray area.
- 452 (h) When it is necessary for staff to hold an animal during  
453 radiography, wherever practicable, the same person must not  
454 always be called on to do this.
- 455
- 456 3.7.3 The radiography of large animals, e.g. horses and cattle, creates  
457 additional problems in relation to radiation hazards for the following  
458 reasons:
- 459 (a) It is seldom practicable to anaesthetise the animal and some  
460 form of manual restraint is likely to be needed.
- 461 (b) It is often necessary for the film cassette holder to be supported  
462 manually.
- 463 (c) It is usually necessary for the useful beam to be directed  
464 horizontally, posing a greater risk of irradiating assistants.
- 465 (d) Those who restrain the animal or support the cassette holder are  
466 more likely to have their attention concentrated on their task  
467 rather than on avoiding the useful beam.
- 468 (e) The illumination of the light beam collimator may be ineffective  
469 due to the light levels out of doors and in such circumstances  
470 there is a tendency to increase the area of the X-ray beam to an  
471 excessive size. From this point of view, it is preferable for  
472 outdoor radiography to be done in the shade.
- 473
- 474 3.7.4 Radiographic examinations of large animals, for regions other than the  
475 lower limbs, require the use of considerably greater exposure factors  
476 that increases the hazard from both the primary beam and scattered  
477 radiation and must only be carried out using high-powered X-ray  
478 equipment at a fixed installation.
- 479
- 480 3.7.5 In view of the additional radiation hazards in radiography of large  
481 animals, there is a particular responsibility to ensure that, despite all  
482 difficulties, all precautions are observed and particularly the following:
- 483 (a) all assistants must wear sufficient protective clothing to give full  
484 protection from the source of radiation<sup>11</sup>;
- 485 (b) all assistants not immediately required for the procedure must  
486 remain as far away as practicable, and at least 2 m from the  
487 beam.
- 488 (c) the animal must, whenever possible, be suitably tranquillised or  
489 anaesthetised before radiography.

---

<sup>10</sup> Pregnant women should be at least 2 m from the edge of the beam during radiography.

<sup>11</sup> For example, it may be necessary to protect the legs.

490 **3.8 FACILITIES - GENERAL**

491

492 3.8.1 In general, radiography may be considered in two categories.

493 (a) Radiography within a defined X-ray room or area.

494 (b) Radiography outside a defined X-ray room or area when a  
495 mobile or portable X-ray machine is taken to the animal.

496

497 3.8.2 X-ray machines must have sufficient capacity to provide radiographs  
498 of good diagnostic quality.

499

500 3.8.3 Despite the provisions of Clause 3.8.4, the Responsible Person must  
501 provide adequate facilities to ensure:

502 (a) physical control over the animal; and

503 (b) protection of the operator.

504

505 3.8.4 X-ray examinations must not be carried out outside a defined X-ray  
506 room or area unless it is not practicable to bring the animal to that  
507 room or area.

508

509 3.8.5 To ensure maximum protection for staff and visitors, all X-ray  
510 equipment must meet the following requirements:

511 (a) **Warning signs:** the X-ray control panel must bear a  
512 permanent and conspicuous sign prohibiting unauthorised use  
513 and warning that hazardous X-radiation is emitted when the  
514 equipment is in operation;

515 (b) **Markings:** all controls, meters, lights and other indicators  
516 relevant to the operation of the equipment must be readily  
517 discernible and clearly labelled as to function;

518 (c) **Irradiation Indicator:** there must be a readily discernible  
519 separate indicator on the control panel that indicates when  
520 X-rays are being produced;

521 (d) **Mechanical Stability:** the X-ray tube must be securely fixed  
522 and correctly aligned within the X-ray tube housing;

523 (e) The X-ray **source assembly** must maintain its required  
524 position without excessive drift, oscillation or vibration during  
525 operation;

526 (f) **Irradiation Control:** there must be an irradiation switch,  
527 timer, or other device to initiate and terminate X-ray  
528 production;

529 (g) where an irradiation switch is provided, it must require  
530 continuous pressure by the operator to produce X-rays;

531 (h) where a foot switch is provided, it must be constructed so that  
532 X-rays cannot be produced by any accidental activation of the  
533 switch;

534 (i) the irradiation timer must be an electronic type;

- 535 (j) mechanical timers must not be used;
- 536 (k) **Indication of Loading Factors:** for X-ray equipment having  
 537 adjustable loading factors, the control panel must incorporate  
 538 indicators that allow these loading factors to be determined<sup>12</sup>;
- 539 (l) **Irradiation Reproducibility:** for any selected combination of  
 540 X-ray tube voltage, current and time, the coefficient of  
 541 variation<sup>13</sup> of any 5 consecutive irradiations taken at the same  
 542 distance within a period of 10 minutes must not exceed 0.05;
- 543 (m) **X-ray Tube Shielding:** the X-ray tube must be enclosed in a  
 544 shielded housing;
- 545 (n) The leakage radiation from the X-ray tube housing must not  
 546 exceed 1 mGy in 1 hour at 1 metre from the focal spot at the  
 547 nominal X-ray tube voltage of the equipment, which is the  
 548 maximum voltage at which it can be operated;
- 549 (o) **Half-Value Layer:** for a given kilovoltage peak (kVp) specified  
 550 in column 2 of Table 1, the measured value of half-value layer of  
 551 the useful beam must not be less than the level specified in  
 552 column 3 of Table 1:  
 553

---

<sup>12</sup> For equipment having non-adjustable loading factors, permanent marks or labels may be used to indicate these parameters.

<sup>13</sup> The coefficient of variation is defined as 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 C = coefficient of variation  
 X<sub>i</sub> = i<sup>th</sup> measurement  
 $\bar{x}$  = mean value of measurements  
 S = estimated standard deviation  
 n = number of measurements

**TABLE 1 HALF VALUE LAYERS**

<b>Column 1</b>	<b>Column 2</b>	<b>Column 3</b>
<b>Equipment Type</b>	<b>Operating Potential kilovolt peak (kVp)</b>	<b>Half Value Layer (mm Al. eq.)</b>
Equipment designed to operate with X-ray tube potentials up to 120 kilovolts peak (kVp)	50	1.5
	60	1.6
	70	1.8
	80	2.1
	90	2.3
	100	2.6
	110	2.9
	120	3.2
Equipment designed to operate with X-ray tube potentials above 120 kVp	130	3.5
	140	3.8
	150	4.1

554

555 **3.9 FACILITIES - RADIOGRAPHY**

556

557 3.9.1 In addition to the general requirements for veterinary radiology  
558 equipment specified in Section 3.8, the following requirements apply  
559 for equipment used for radiography:

560 (a) the irradiation control device must automatically terminate the  
561 irradiation after a preset time, product of tube current and time,  
562 or irradiation value has been reached;

563 (b) **Light Beam Collimator (LBC)**: the X-ray tube housing must  
564 be equipped with a light beam collimator that:

565 (i) enables adjustment of the size of the X-ray field; and

566 (ii) incorporates means to indicate the size of the X-ray field  
567 at the image reception area.

568 (c) The LBC must meet the following requirements:

569 (i) the respective edges of the X-ray field along either the  
570 length or the width of the visually defined field must not  
571 exceed 1% of the distance from the source to the centre of  
572 the visually defined field when the surface on which it  
573 appears is perpendicular to the central axis of the useful  
574 X-ray beam;

575 (ii) the visually defined field (light field) must contain cross-  
576 wires or other acceptable mode of indicating the centre of  
577 the X-ray beam (dark cross-wires on an illuminated field  
578 are preferred to illuminated cross wires on a dark field.);

579 (iii) the centre of the X-ray beam and indicated centre of the  
580 light beam must correspond to an accuracy of within 1%  
581 of the distance from the source to the point on the  
582 illuminated surface at which it appears.

583 (iv) the brightness of the light field must be sufficiently great  
584 that the light field is clearly visible in ambient  
585 illumination<sup>14</sup>.  
586

### 587 **3.10 FACILITIES – FLUOROSCOPY**

588  
589 3.10.1 In addition to the general requirements for veterinary radiology  
590 equipment specified in Section 3.8, the following requirements apply  
591 for equipment used for fluoroscopy:

- 592 (a) an X-ray image intensification system must be used;
- 593 (b) the X-ray image intensification system must be properly  
594 installed and maintained.
- 595 (c) a remote television display must be used for group viewing and  
596 teaching purposes.
- 597 (d) the performance of fluoroscopy equipment must comply with  
598 the relevant Australian Standard in relation to:
- 599 (i) air **kerma** rates during fluoroscopy; and  
600 (ii) image intensifier performance,
- 601 (e) air kerma rates during fluoroscopy must not exceed the values  
602 given in Table 2 measured under the conditions given in Table 3;
- 603 (f) the air kerma rates at the input surface of image intensifiers  
604 must not exceed the values given in Table 4 below:  
605  
606

607 **TABLE 2 AIR KERMA RATES DURING FLUOROSCOPY**

Manual	Automatic	High level (boost) <sup>15</sup>
50 mGy/min	100 mGy/min	150 mGy/min

608  
609

---

<sup>14</sup> The outer edges of the light field should be clearly shown with a high edge-field contrast ratio.

<sup>15</sup> High level (boost) mode should only be accessed through the automatic mode of operation.

610

**TABLE 3 TEST CONDITIONS**

<b>Conditions</b>	<b>Measurement distance</b>
<b>UNDER-TABLE X-RAY TUBE</b> When a patient support is permanently between the X-ray tube assembly and the position of the patient.	10 mm from the patient support on the patient side of the support.
<b>OVER-TABLE X-RAY TUBE</b> When a patient support is permanently between the position of the patient and the X-ray image receptor.	300 mm above the patient support on the X-ray tube side of the support.
<b>C- OR U- ARM SYSTEMS</b> Where the X-ray tube and the image receptor are mechanically linked and where a patient 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.
<b>OTHER RADIOSCOPY SYSTEMS</b> Where no patient support is permanently in the radiation beam.	400 mm from the focal spot or the minimum distance, whichever is greater.

611

612

613

**TABLE 4 AIR KERMA RATES AT THE FIELD INPUT SURFACE**

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

**MEASUREMENT CONDITIONS**  
The measurement conditions must 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 manual systems, these air kerma rates should not be exceeded for the normal clinical settings when used with average patients.

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

614

**3.11 VETERINARY DENTAL X-RAY EQUIPMENT**

616

617 3.11.1 Dental X-ray units used for veterinary purposes must comply with the  
618 requirements of the relevant regulatory authority.

619

620 3.11.2 For dental examinations, a dental X-ray unit with appropriate  
621 collimation must be used rather than a standard X-ray unit<sup>16</sup>.

622

<sup>16</sup> 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.

623 **3.12 CAPACITOR DISCHARGE X-RAY EQUIPMENT**<sup>17</sup>

624

625 3.12.1 If a capacitor discharge X-ray unit is used, special care must be taken<sup>18</sup>.

626

627 3.12.2 Advice must be sought from the relevant regulatory authority before a  
628 capacitor discharge X-ray unit is put into service.

629

630 3.12.3 Each capacitor discharge X-ray unit must meet the relevant  
631 requirements of Sections 3.8 and 0.

632

633 3.12.4 In addition to the requirements of Clause 3.12.3, each capacitor  
634 discharge X-ray unit must be fitted with a device that:

635 (a) when the exposure switch is not activated, ensures that the air  
636 kerma rate from any accessible surface of the X-ray tube  
637 housing, including the associated diaphragm or light beam  
638 collimator, does not exceed 20  $\mu\text{Gy}\cdot\text{h}^{-1}$  at 0.05 m<sup>19</sup> even when the  
639 collimator is fully open;

640 (b) enables the capacitor(s) to be discharged while complying with  
641 Sub-clause (a).

642

643 **3.13 ANCILLARY EQUIPMENT**

644

645 3.13.1 An examination table must be provided with protective shielding  
646 equivalent to 1.0 mm lead (or the nearest commercially available  
647 thickness e.g. 10 kg per square metre) underneath the table-top or any  
648 Potter-Bucky diaphragm incorporated in the table<sup>20,21</sup>.

649

650 3.13.2 Sand bags, V-troughs, slings, adhesive tape or other positioning and  
651 immobilising devices must be available for supporting the animal  
652 during radiography (see Annex 2).

653

654 3.13.3 Suitable cassette holders must be available for use when using  
655 horizontal or angled X-ray beams.

656

657 3.13.4 Where cassette holders are not self-supporting, they must be fitted  
658 with:

659 (a) handles at least 1 metre long; and

660 (b) a ground support,

661 to ensure that a person holding them can remain well outside the  
662 primary beam.

663

---

<sup>17</sup> These units are often known as 'CD mobiles' or 'CD X-ray units'.

<sup>18</sup> If a capacitor discharge X-ray unit is not fitted with the type of device specified in 3.12.4, the operator or staff may be unwittingly exposed to the primary X-ray beam.

<sup>19</sup> Such a device is commonly known as a 'blackout' shutter.

<sup>20</sup> A tabletop of 5 mm steel is a satisfactory alternative.

<sup>21</sup> For ease of cleaning and to prevent mechanical damage, the lead shielding should be covered with laminated plastic sheeting.

- 664 3.13.5 Personal protective devices made of lead impregnated rubber or plastic  
665 such as aprons<sup>22</sup>, gloves and shields suitable for hand and forearm  
666 protection, must be provided for all persons who are:
- 667 (a) required to be present during radiography; and  
668 (b) not protected by fixed or mobile protective screens.  
669
- 670 3.13.6 Personal protective devices must have a lead-equivalent thickness  
671 throughout of not less than:
- 672 (a) 0.25 millimetre; and  
673 (b) 0.5 millimetre when energies above 100 kV peak are used.  
674
- 675 3.13.7 The Responsible Person must ensure that testing of personal  
676 protective devices<sup>23</sup> is carried out:
- 677 (a) at regular intervals of no more than 12 months; or  
678 (b) more frequently if damage is expected.  
679
- 680 3.13.8 The Responsible Person must ensure that records of tests of personal  
681 protective devices are kept.  
682

---

<sup>22</sup> When not in use, aprons should be hung without folds on appropriate hangers.

<sup>23</sup> 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 which could be caused by claws, animal bites or other damage.

## 683 **4. Radiotherapy**

684

### 685 **4.1 PROCEDURES AND FACILITIES**

686

687 4.1.1 The licensing requirements of the relevant regulatory authority in  
688 relation to radiotherapy must be observed.

689

690 4.1.2 The potential hazards are greater in radiotherapy than in the  
691 diagnostic use of radiation because of the larger exposures involved  
692 (often more than 1000 times those used in radiography) and also, in  
693 many cases, because of the use of more penetrating radiations.

694

695 4.1.3 Radiotherapy of animal patients must only be performed by, or under  
696 the direct supervision of, personnel:

697

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

698

(b) who are authorised as required by the relevant regulatory  
699 authority.

700

701 4.1.4 The therapeutic use of radiation on animals must only be undertaken  
702 using special equipment and facilities designed for the purpose.

703

704 4.1.5 The facilities for the treatment and housing of the animal must be  
705 adequate for protection of:

706

(a) the persons caring for the animal; and

707

(b) other persons in the vicinity.

708

709 4.1.6 The safe use of sealed **radioactive sources** that emit **gamma**  
710 **radiation** requires considerable expertise hence persons using them  
711 in radiotherapy must have adequate training and extensive supervised  
712 experience in the handling of radioactive materials for therapeutic  
713 purposes<sup>24</sup>.

714

### 715 **4.2 X-RAY THERAPY EQUIPMENT**

716

717 4.2.1 X-ray therapy machines must be of a type:

718

(a) designed specifically for therapy; and

719

(b) appropriate for X-ray therapy.

720

721 4.2.2 X-ray therapy machines must conform with the normal safety  
722 requirements for medical X-ray therapy equipment and in particular:

723

(a) The limitation of leakage radiation through the X-ray tube  
724 housing and the beam defining applicators must be such that the  
725 air-kerma rate from the leakage radiation, for every specified  
726 rating of the X-ray tube in the housing, does not exceed:

727

(i) 10 mGy h<sup>-1</sup> at a distance of 1 m from the focus; or

---

<sup>24</sup> The use of such sources represents the possibility of greater hazard than the use of X-ray therapy machines.

- 728 (ii) 300 mGy.h<sup>-1</sup> at any accessible position at a distance of  
729 0.5 m from the surface of the housing and the applicator,
- 730 (b) The X-ray tube must be so mounted that it cannot turn or slide  
731 with respect to the housing aperture.
- 732 (c) A mark on the housing must show the location of the focal spot.
- 733 (d) A suitable exposure control device (timer or exposure meter)  
734 must be provided to terminate the exposure after a preset time  
735 interval or a preset exposure limit.
- 736 (e) An easily discernible indicator must be provided on the control  
737 panel that shows when X-rays are being produced.
- 738 (f) With apparatus capable of operating at X-ray tube voltages  
739 above 100 kV, interlocks must be provided that preclude entry to  
740 the treatment room while the equipment is in operation and:
- 741 (i) the interlocks must be of a fail-safe type which interrupt  
742 the radiation treatment when the door to the treatment  
743 room is opened;
- 744 (ii) after a radiation treatment is interrupted by the operation  
745 of an interlock, it must only be possible to finally restore  
746 the apparatus to full operation from the control panel;
- 747 (iii) the functioning of interlocks must be tested and  
748 maintained at regular intervals.
- 749 (g) All beam-therapy equipment must be tested for performance  
750 and calibrated by a qualified expert:
- 751 (i) before it is first put into use for treatment; and
- 752 (ii) at regular intervals thereafter as specified by the relevant  
753 regulatory authority.
- 754 (h) All beam-therapy equipment must be tested and calibrated after  
755 any major overhaul or service.
- 756
- 757 4.2.3 The control station or control position for an X-ray therapy machine  
758 must be:
- 759 (a) outside the treatment area; or
- 760 (b) behind an adequate protective barrier.
- 761
- 762 4.2.4 The animal must be observable from the control position.
- 763
- 764 4.2.5 The control panel and the animal must be kept under observation  
765 during exposure.
- 766
- 767 4.2.6 Radiation therapy may be conducted within a special lead lined box  
768 that provides the same degree of attenuation as is required of the tube  
769 housing and accessory equipment.
- 770
- 771 4.2.7 The animal must be adequately immobilised for treatment.
- 772

- 773 4.2.8 No person must remain in the treatment area during the time the  
774 X-ray beam is on.  
775
- 776 4.2.9 All shielding requirements for defined X-ray treatment areas, rooms,  
777 enclosures and protective barriers must be as required by the relevant  
778 regulatory authority.  
779
- 780 4.2.10 X-ray warning signs must be displayed at all entrances as required by  
781 the relevant regulatory authority (see Annex 4).  
782
- 783 4.2.11 X-ray therapy equipment must not be used to treat animals until the  
784 radiation safety of the installation has been:
- 785 (a) established by a protection survey; and  
786 (b) approved by the relevant regulatory authority.  
787

### 788 **4.3 SEALED RADIOACTIVE SOURCES – GAMMA-RAY EMITTERS**

- 789
- 790 4.3.1 In all cases where sealed radioactive sources are used, the Responsible  
791 Person must ensure that:
- 792 (a) the storage and handling of the sources is in accordance with the  
793 requirements of the relevant regulatory authority;
- 794 (b) an up-to-date register is maintained of all sealed radioactive  
795 sources that includes details of:
- 796 (i) where appropriate, the serial number or other  
797 identification of each sealed source;
- 798 (ii) the physical or chemical form of the **radioactive**  
799 **substance** in the source;
- 800 (iii) a photograph or diagram of the source;
- 801 (iv) the date of receipt and its **activity** on that date; and
- 802 (v) the date and manner of ultimate disposal (including those  
803 sources permanently implanted in animals).
- 804 (c) a dose rate monitoring instrument in good working order and  
805 suitable for the type of radiation being used is readily available.
- 806 (d) an appropriate approved personal radiation dosimeter is worn  
807 by each person handling radioactive materials (see Section 7.1).  
808
- 809 4.3.2 At all times during the use of removable sealed radioactive sources in  
810 treatment, the Responsible Person must ensure that:
- 811 (a) the animal is housed under regular supervision in strictly secure  
812 circumstances in an enclosure<sup>25</sup> set aside for that purpose;
- 813 (b) escape of the animal with sources in situ is most unlikely;
- 814 (c) the enclosure is located in a position that is at least 3 metres  
815 from any normally occupied areas;

---

<sup>25</sup> For example, a kennel, box or stall.

- 816 (d) the enclosure is located as far as practicable from frequently  
817 used corridors, passageways or other thoroughfares;
- 818 (e) the sealed radioactive sources to be used are taken into the  
819 enclosure in their shielded container and then applied directly to  
820 the animal;
- 821 (f) upon removal of the sources from the animal and before the  
822 animal is released from the enclosure, the sealed radioactive  
823 sources are:
- 824 (i) checked;
- 825 (ii) all accounted for;
- 826 (iii) immediately returned into the shielded container; and  
827 (iv) returned to the store.
- 828 (g) if any damage to sources is observed following removal from the  
829 animal, the person responsible for the radioactive material is  
830 notified as soon as possible;
- 831 (h) no person enters the enclosure apart from essential feeding and  
832 care of the animal;
- 833 (i) access to the area is limited to about 15 minutes a day per  
834 person;
- 835 (j) persons do not stay within one metre of the enclosure  
836 unnecessarily;
- 837 (k) children, pregnant women and other members of the public are  
838 not in the vicinity during radiotherapy;
- 839 (l) particular care is taken in the application of the sources and in  
840 the care of the animal to safeguard the sources from dislodgment  
841 and/or damage during treatment;
- 842 (m) if a radioactive mould or applicator slips or becomes dislodged,  
843 the person responsible for the radioactive material is notified as  
844 soon as possible;
- 845 (n) adequate arrangements are provided for immediate response in  
846 case of an emergency; and
- 847 (o) an appropriate radiation warning sign and instructions as  
848 specified in Sub-clauses (i) and (j) are displayed on the  
849 enclosure.
- 850
- 851 4.3.3 In the case of permanent implantation of radioactive sources into an  
852 animal, the animal must be housed and attended to as in Sub-clauses  
853 4.3.2(a)-(d) unless or until the total activity in the animal is less than  
854 that indicated below:
- 855 (a) for companion animals (i.e. domestic pets or animals normally  
856 in regular contact with humans):
- 857 (i) gold-198 — 1200 MBq (~ 32 mCi);
- 858 (b) for field animals (i.e. animals normally held in a paddock or very  
859 large yard and not in contact with humans):

- 860 (i) gold-198 — 6000 MBq (~ 160 mCi);  
861 (c) for other radioactive materials the relevant regulatory authority  
862 must be consulted.  
863
- 864 4.3.4 For companion animals, the housing and care referred to in  
865 Sub-clauses 4.3.2(a) to 4.3.2(d) above must be at the premises of the  
866 veterinary surgeon or person authorised by the relevant regulatory  
867 authority.  
868
- 869 4.3.5 When the activity of the source is less than the values given in  
870 Clause 4.3.3 and the animal is released into the custody of an adult,  
871 the Responsible Person must provide that person with appropriate  
872 written instructions including that:
- 873 (a) apart from essential feeding and care, persons not remain closer  
874 than one metre from the animal for 4 days after discharge of the  
875 patient;
- 876 (b) no animal be ridden, groomed or have any extensive contact  
877 with humans until at least 14 days after discharge;
- 878 (c) if any radioactive seed or grain from the implant becomes  
879 accidentally dislodged, it is only carefully picked up using  
880 tweezers, pliers or other long-handled implements, placed in a  
881 suitable shielded container and kept in safe custody until  
882 disposed of by means approved by the relevant regulatory  
883 authority; and
- 884 (d) on no account must any radioactive seed or grain be handled in  
885 the fingers or kept as a curio.  
886
- 887 4.3.6 If an animal dies before treatment is completed, the Responsible  
888 Person must ensure that:
- 889 (a) in the case of removable sources, the person responsible for the  
890 radioactive material:
- 891 (i) is notified as soon as possible; and  
892 (ii) arranges for removal of the sources;
- 893 (b) in the case of permanently implanted sources, the carcass is only  
894 disposed of by means approved by the relevant regulatory  
895 authority.  
896

#### 897 **4.4 SEALED RADIOACTIVE SOURCES – BETA PARTICLE EMITTERS**

898

899 The only beta particle emitting radioactive element in common use as a sealed  
900 source in radiotherapy is strontium-90. This is made up in a form suitable for  
901 surface application to thin accessible lesions. A description of strontium-90  
902 applicators and directions for their use, care, storage, transport and safe  
903 handling and disposal is given in Annex 5.  
904

905 It is stressed that a strontium-90 applicator, although appearing quite  
906 innocuous, is a very delicate and potentially hazardous device.  
907

- 908 4.4.1 Strontium-90 applicators must only be used by persons specifically  
909 licensed to do so.  
910
- 911 4.4.2 A strontium applicator must be stored in a container that is designed:  
912 (a) with the smallest overall external dimension of the box not less  
913 than 0.1 m;  
914 (b) to protect the plate from damage;  
915 (c) to provide adequate radiation shielding; and  
916 (d) so that the plate cannot move or be dislodged during transport.  
917
- 918 4.4.3 The outside of the storage container must be labelled with the:  
919 (a) appropriate radiation warning symbol;  
920 (b) name of the radioactive element (strontium-90);  
921 (c) nominal activity;  
922 (d) date of measurement of the activity;  
923 (e) name of the Responsible Person, address and contact telephone  
924 number.  
925
- 926 4.4.4 The loss of an applicator must be reported to the relevant regulatory  
927 authority as soon as possible.  
928
- 929 4.4.5 The applicator must always be manipulated using a permanently  
930 attached or long screw-in handle or long-handled forceps applied to  
931 the boss or lug on the back of the applicator.  
932
- 933 4.4.6 The active face of the plate must not be viewed directly.  
934
- 935 4.4.7 Forceps, scalpel blade or any other such instrument must not be used  
936 on the face of the plate.  
937
- 938 4.4.8 Cold sterilisation only must be employed.  
939
- 940 4.4.9 The plate must always be kept in its special container:  
941 (a) when not in use; or  
942 (b) when being transported.  
943
- 944 4.4.10 Strontium plates must be checked periodically for radioactive leakage  
945 at regular intervals, not exceeding one year.  
946
- 947 4.4.11 A plate that has been damaged in any way<sup>26</sup> must be returned  
948 immediately to an appropriate, accredited body for checking, possible  
949 repair and testing for radioactive leakage.  
950
- 951 4.4.12 Strontium-90 applicators must only be disposed of as prescribed by  
952 the relevant regulatory authority.

---

<sup>26</sup> For example, the boss broken off or the flat active section bent or scratched.

953 **5. Diagnostic and Therapeutic Nuclear**  
954 **Medicine**

955  
956 **5.1 PROCEDURES AND FACILITIES**  
957

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

963  
964 5.1.1 Diagnostic veterinary nuclear medicine must only be undertaken by  
965 personnel who:

- 966 (a) are specifically trained in the following disciplines:  
967 (i) radiation physics;  
968 (ii) radiation biology; and  
969 (iii) radiation hazards & protection,  
970 (b) have practical experience in:  
971 (i) nuclear medicine instrumentation;  
972 (ii) imaging procedures;  
973 (iii) quality control;  
974 (iv) the handling of unsealed radioactive materials; and  
975 (v) hot laboratory procedures & clinical practice, and  
976 (c) are licensed as required by the relevant regulatory authority.

977  
978 5.1.2 Therapeutic veterinary nuclear medicine must only be undertaken by  
979 personnel who:

- 980 (a) meet the requirements specified in Clause 5.1.1; and  
981 (b) have additional training in:  
982 (i) the biological pathways and distribution of radioactive  
983 materials;  
984 (ii) radiation dosimetry;  
985 (iii) experience in spillage procedures; and  
986 (iv) handling radioactive waste at levels encountered in  
987 therapy.

988  
989 5.1.3 The Responsible Person must ensure that special dedicated facilities  
990 are provided for storage, safe handling, manipulation and dispensing of  
991 unsealed radioactive sources.

992  
993 5.1.4 Diagnostic or therapeutic nuclear medicine procedures must only take  
994 place in areas specified in Clause 5.1.3 that are specifically designed for  
995 the purpose.

- 996 5.1.5 Approval of the design must be obtained from the relevant regulatory  
997 authority before the commissioning of such facilities.  
998
- 999 5.1.6 An appropriate approved personal radiation dosimeter must be worn  
1000 by each person handling unsealed radioactive materials (see  
1001 Section 7.1).  
1002
- 1003 5.1.7 The Responsible Person must ensure that a suitable radiation survey  
1004 meter that meets the requirements of Schedule B of this Code is readily  
1005 available or accessible<sup>27</sup> to monitor the gamma radiation levels for  
1006 diagnostic and therapeutic nuclear medicine procedures.  
1007
- 1008 5.1.8 All persons handling radioactive materials, animals, cages, food  
1009 containers and excreta<sup>28</sup> must wear gowns and disposable gloves.  
1010
- 1011 5.1.9 Specially designed cages or other enclosures must be used to limit the  
1012 spread of and contamination by the radioactive material.  
1013
- 1014 5.1.10 Detailed written procedures for decontamination and for the disposal  
1015 of radioactive waste must be developed and approved by the relevant  
1016 regulatory authority.  
1017
- 1018 5.1.11 Suitable arrangements must be made for the subsequent discharge or  
1019 disposal of animals.  
1020
- 1021 5.1.12 Dedicated facilities must be used for nuclear medicine procedures for:  
1022 (a) administration of unsealed radioactive materials to animals;  
1023 (b) subsequent housing of the animals;  
1024 (c) measurements of the radioactive materials in the animals and  
1025 any subsequent investigations; or  
1026 (d) housing of the animals before discharge once the studies are  
1027 completed.  
1028
- 1029 5.1.13 The facilities prescribed in Clause 5.1.12 must be approved by the  
1030 relevant regulatory authority before commissioning.  
1031
- 1032 5.1.14 Written protocols for each type of nuclear medicine procedure must be  
1033 developed and approved by the relevant regulatory authority before the  
1034 procedures are implemented.  
1035
- 1036 5.1.15 Appropriate radiation warning signs and instructions must be  
1037 displayed on the kennel, box, stall or other enclosure.

---

<sup>27</sup> 'Readily available or accessible' means that the person can obtain a survey meter within a reasonable time. This may be achieved by borrowing, hiring or sharing a survey meter. Details of how the availability or accessibility of the survey meter are 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, **supplier** or service provider from the survey monitoring requirements of this Code.

<sup>28</sup> Excretion of radioactive materials may be via urine, faeces, saliva, exhaled breath or the skin.

1038 5.1.16 A record of the receipt, use and disposal of all radionuclides must be  
1039 maintained.  
1040

## 1041 **5.2 SPECIFIC NUCLEAR MEDICINE PROCEDURES**

1042  
1043 5.2.1 *Technetium-99m labelled bone-seeking agent for bone imaging:* The  
1044 Responsible Person must ensure that the following special  
1045 requirements and considerations are implemented when using  
1046 technetium-99m labelled bone-seeking agent for bone imaging:

1047 (a) an isolated, shielded and secure accommodation is used for  
1048 administering the radioactive material and hospitalising the  
1049 animal until the day after the administration<sup>29</sup>;

1050 (b) a separate shielded and secure location is used for the imaging  
1051 procedure;

1052 (c) the walls and fixtures in areas prescribed in Sub-clauses (a) and  
1053 (b) are waterproof 'non-slip', or painted with waterproof paint so  
1054 that they can be hosed down to remove any radioactive  
1055 contamination;

1056 (d) the floors are sealed;

1057 (e) drainage is provided to the normal establishment waste;

1058 (f) the flooring material:

1059 (i) is readily cleanable;

1060 (ii) covers the whole imaging area; and

1061 (iii) is sealed or covered up at the edges,

1062 (g) as production of radioactive urine in the imaging area could not  
1063 only be hazardous but could also interfere with the imaging  
1064 process, procedures to minimise this possibility by the prior use  
1065 of an appropriate diuretic are considered;

1066 (h) decontamination equipment is available for easy and rapid  
1067 decontamination of the area;

1068 (i) bedding material is absorbent;

1069 (j) contaminated bedding and other material from the area is  
1070 disposed of after 24 hours,

1071 (k) entry to the area is prohibited between the time of injection and  
1072 the time of removal of the animal for the imaging procedure;

1073 (l) a syringe shield is used for the injection of the radioactive  
1074 technetium;

1075 (m) all personnel involved be made aware that they are handling a  
1076 radioactive animal;

1077 (n) the procedures and precautions are explained to all personnel  
1078 involved with handling a radioactive animal;

---

<sup>29</sup> For the normal doses of technetium-99m used in bone imaging, the animal may be discharged the day after administration of the dose.

- 1079 (o) procedures are carefully planned;
- 1080 (p) persons required to be in close proximity to the animal for the  
1081 imaging procedure wear lead protective aprons of a minimum  
1082 0.5 mm lead equivalent thickness;
- 1083 (q) provision is made for appropriate shielding of the operator at the  
1084 imaging console;
- 1085 (r) suitable animal restraints e.g. stocks, are provided to minimise  
1086 handling of the radioactive animal during imaging or other  
1087 procedures;
- 1088 (s) the animal is sedated as appropriate for the period of the  
1089 imaging procedure;
- 1090 (t) persons under the age of 18 years and pregnant women do not  
1091 hold animals during nuclear medicine procedures;
- 1092 (u) a notice advising of the requirement of Sub-clause (t) is  
1093 displayed prominently in the area; and
- 1094 (v) radiography or other clinical investigations required are delayed  
1095 until the day after the administration of the technetium.  
1096

1097 *5.2.2 Treatment of feline hyperthyroidism with iodine-131<sup>30</sup>: The*  
1098 *Responsible Person must ensure that the following special*  
1099 *requirements and considerations are implemented for the treatment of*  
1100 *feline hyperthyroidism with iodine-131:*

- 1101 (a) an isolated, shielded, well ventilated and secure area is provided  
1102 for:
- 1103 (i) administering the radioactive material; and
- 1104 (ii) hospitalising the cats for at least 5 days after the  
1105 administration,
- 1106 (b) an extraction fan is installed unless there is very good natural  
1107 ventilation;
- 1108 (c) the cat is lightly tranquillised and placed in a deep tray<sup>31</sup> lined  
1109 with absorbent paper for administration of the radioactive  
1110 material;
- 1111 (d) the radioactive material is kept in a shielded container until just  
1112 prior to administration;
- 1113 (e) the radioiodine is in capsule form;
- 1114 (f) where possible, long handled forceps are used to insert the  
1115 capsule well down the throat followed by about 20 ml of water  
1116 introduced into the mouth by a syringe;
- 1117 (g) consideration is given to the risk of subsequent vomiting by the  
1118 animal;

---

<sup>30</sup> Iodine is readily volatile and if proper precautions are not taken it is readily vaporised and can be inhaled and accumulate in the body. It may accumulate in poorly ventilated areas and this presents a potential inhalation hazard to persons in the vicinity.

<sup>31</sup> For example, a baby bath.

- 1119 (h) after administration, the cat is handled with disposable gloves  
1120 and held at arm's length when possible;
- 1121 (i) a well ventilated and shielded area is available for storage of  
1122 radioactive waste<sup>32</sup>;
- 1123 (j) all material removed from cages is handled with disposable  
1124 gloves and stored as radioactive waste<sup>33</sup> in accordance with  
1125 detailed safety protocols approved by the relevant regulatory  
1126 authority;
- 1127 (k) an approved written protocol for handling radioactive spillage<sup>34</sup>  
1128 including clean up and monitoring procedures is established;
- 1129 (l) if a cat dies before treatment is completed, it is:
- 1130 (i) sealed in a plastic bag;
- 1131 (ii) stored as radioactive waste in accordance with Sub-clause  
1132 (j) above; and
- 1133 (iii) cremated or released to the owners for immediate burial.
- 1134 (m) where a post mortem examination is required<sup>35</sup>, the subsequent  
1135 treatment of the corpse is as prescribed in Sub-clause (l)(i) to  
1136 (iii) above.
- 1137 (n) the veterinary surgeon provides the owner, at the time of release,  
1138 with written instructions<sup>36</sup> for the handling of the cat for the  
1139 following two weeks which include:
- 1140 (i) instructions to avoid long periods (more than a few  
1141 minutes) in close proximity to the cat, particularly during  
1142 the first week;
- 1143 (ii) information that it is safe to pick up the cat for short  
1144 periods but that it should not sit on any person's lap for  
1145 extended periods or sleep next to any person on a bed;
- 1146 (iii) if the cat urinates inside a dwelling, the urine should be  
1147 cleaned up thoroughly with paper towels which are then  
1148 placed in a rubbish bag;
- 1149 (iv) either rubber gloves be used to cleaning up urine, or wash  
1150 the hands very thoroughly afterwards; and
- 1151 (v) instructions that if the urine has soaked into garments or  
1152 carpets, they should be cleaned thoroughly.

---

<sup>32</sup> The urine may contain up to half of the administered radioactivity in the first 3 days.

<sup>33</sup> Waste containing radioiodine should be stored for at least 6 weeks.

<sup>34</sup> Spillage of radioactive material could occur if the cat bites and punctures the radioactive capsule, or if the cat regurgitates the capsule or its contents.

<sup>35</sup> Where a post mortem examination is required, the procedures normally observed during such examinations are adequate.

<sup>36</sup> If the instructions are followed, the risk from the radiation will be negligible.

---

1153 **6. Lasers**

1154

1155 **6.1 GENERAL REQUIREMENTS FOR PROTECTION**

1156

1157 6.1.1 The Responsible Person must ensure that:

1158 (a) the requirements of Australian/New Zealand Standard AS/NZS  
1159 2211.1 – Part 1:1997 are observed;

1160 (b) the requirements of the relevant regulatory authority are  
1161 observed;

1162 (c) no person is exposed to laser radiation above the maximum  
1163 permissible exposure levels; and

1164 (d) each operator of laser equipment has undertaken laser safety  
1165 training approved by the relevant regulatory authority;

1166 (e) apparatus is not modified;

1167 (f) safe working practices involving the use of laser apparatus are  
1168 developed and documented<sup>37</sup>;

1169 (g) appropriate training of all staff involved with the use of lasers is  
1170 implemented.

1171

1172 6.1.2 The Responsible Person must ensure that the laser facility:

1173 (a) is adequately ventilated;

1174 (b) has adequate (opaque) window coverings;

1175 (c) has adequate fire suppression equipment;

1176 (d) is adequately signposted with an approved laser warning sign;  
1177 and

1178 (e) meets all requirements of the relevant regulatory authority for a  
1179 laser facility.

1180

1181 6.1.3 The Responsible Person must ensure that a Laser Safety Officer (who  
1182 may also be the Responsible Person) knowledgeable in laser safety  
1183 issues is appointed to supervise the use of laser equipment.

1184

1185 **6.2 PROTECTIVE EYEWEAR**

1186

1187 6.2.1 The Responsible Person must ensure that protective eyewear:

1188 (a) is available, consistent with the appropriate standards; and

1189 (b) worn by each person involved with a laser procedure.

---

<sup>37</sup> General information on lasers and laser safety can be found in Annex 6.

1190 **7. Personal Radiation Monitoring**

1191

1192 **7.1 PERSONAL MONITORING DEVICES**

1193

1194 7.1.1 The Responsible Person must provide a personal monitoring device  
1195 approved by the relevant regulatory authority to determine radiation  
1196 doses received by each person who:

1197 (a) may be exposed to radiation from veterinary radiation equipment  
1198 or radioactive source;

1199 (b) performs **routine maintenance** on veterinary radiation  
1200 equipment or radioactive source; or

1201 (c) undertakes service or repair of veterinary radiation equipment or  
1202 radioactive source.

1203

1204 7.1.2 A person who is involved with the service or repair of veterinary  
1205 radiation equipment or radioactive sources must wear a personal  
1206 monitoring device or other monitoring device approved by the relevant  
1207 regulatory authority at all times while that person may be exposed to  
1208 radiation from the equipment or source.

1209

1210 7.1.3 The Responsible Person must ensure that the personal monitoring  
1211 devices provided to each person are capable of measuring the type of  
1212 radiation emitted by the veterinary radiation equipment or radioactive  
1213 source being used.

1214

1215 **7.2 RADIATION DOSE RECORDS**

1216

1217 7.2.1 The Responsible Person must maintain radiation dose records for each  
1218 person occupationally exposed to radiation.

1219

1220 7.2.2 Radiation dose records must show:

1221 (a) doses assessed during the present period of employment; and

1222 (b) doses assessed as a result of any previous employment in which  
1223 ionizing radiations were used.

1224

1225 7.2.3 Radiation dose records must be available for inspection by:

1226 (a) the individual to whom the record applies; and

1227 (b) the relevant regulatory authority.

1228

1229 **Schedule A**

1230

1231 **ARPANSA’s Recommendations for limiting exposure to**  
 1232 **ionizing radiation (2002) – Dose Limits**

1233

Application	Dose Limits <sup>1</sup>	
	Occupational	Public
Effective dose	20 mSv per year, averaged over a period of 5 consecutive calendar years <sup>2,3</sup>	1 mSv in a year <sup>4</sup>
Annual <b>equivalent dose</b> in:		
the lens of the eye	150 mSv	15 mSv
the skin <sup>5</sup>	500 mSv	50 mSv
the hands and feet	500 mSv	–

1234

1235 1 The limits shall apply to the sum of the relevant doses from external exposure  
 1236 in the specified period and the 50-year committed dose (to age 70 years for  
 1237 children) from intakes in the same period.

1238 2 With the further provision that the effective dose shall not exceed 50 mSv in  
 1239 any single year. In addition, when a pregnancy is declared by a female  
 1240 employee, the embryo or fetus should be afforded the same level of protection  
 1241 as required for members of the public.

1242 3 (DELETED)

1243 4 In special circumstances, a higher value of effective dose could be allowed in a  
 1244 single year, provided that the average over 5 years does not exceed 1 mSv per  
 1245 year.

1246 5 The equivalent dose limit for the skin applies to the dose averaged over any  
 1247 1 cm<sup>2</sup> area of skin, regardless of the total area exposed.

1248

1249

1250 **NOTE 1:** The above dose limits table has been directly extracted from ARPANSA’s  
 1251 *Recommendations for limiting exposure to ionizing radiation (1995)*,  
 1252 [republished as RPS 1 in 2002]. However, as the Radiation Health Committee  
 1253 now advises that the exceptional circumstances clause is not recommended for  
 1254 use in Australia, note 3 of the table in RPS 1 has been deleted from this Code.

1255 **NOTE 2:** Exposure to radiation from natural sources is generally excluded from  
 1256 occupational or public exposure, except when the exposure is a direct  
 1257 consequence of a practice or is specifically identified by the appropriate authority  
 1258 as requiring control through the implementation of a program of radiation  
 1259 protection. Medical exposure includes doses received by patients undergoing  
 1260 medical diagnosis or therapy, doses received by volunteers in medical research,  
 1261 and doses received knowingly and willingly by persons other than health care  
 1262 workers as a consequence of their proximity to an exposed patient. Dose limits  
 1263 do not apply to exposures from natural sources, except as described above, or to  
 1264 medical exposures.

1265 **Schedule B**

1266

1267 **Survey Meters**

1268

1269 **B1 General requirements of the survey meter**

1270

1271 B1.1 The radiation survey meter required by Clause 4.2.1 must:

1272 (a) have sufficient measurement range to measure **ambient dose**  
1273 **equivalent** rates or **directional dose equivalent** rates, as  
1274 appropriate, at least throughout the ranges of  $1 \mu\text{Sv h}^{-1}$ , or its  
1275 equivalent, to  $500 \mu\text{Sv h}^{-1}$ , or its equivalent, for the radiations emitted  
1276 from the radioactive sources used in veterinary medicine;

1277 (b) continue to indicate, either visibly or audibly, when radiation levels  
1278 exceed the maximum reading in any measurement range; and

1279 (c) indicate the measured quantity with a measurement uncertainty not  
1280 greater than  $\pm 25$  per cent inclusive of uncertainty due to response  
1281 variation with energy over the range of energies of the radiation to be  
1282 measured.

1283

1284 **B2 Calibration of the survey meter**

1285

1286 B2.1 Radiation survey meters must have an operational and calibration check:

1287 (a) prior to initial use;

1288 (b) at intervals not exceeding 12 months; and

1289 (c) following damage or repairs.

1290

1291 B2.2 The calibration of a radiation survey meter must be, in the case of  
1292 electromagnetic radiation, traceable to:

1293 (a) the Australian National Standard of air kerma; or

1294 (b) an equivalent overseas National Standard of air kerma recognised by  
1295 the relevant regulatory authority.

1296

1297

1298 **References**  
1299  
1300 References to be added.  
1301  
1302

1303 **Glossary**

1304

1305 **activity**

1306

1307 the measure of quantity of radioactive materials, except when used in the term  
1308 'human activity'

1309

1310 Activity,  $A$ , is a measure of the amount of a radioactive material given by:

1311

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

1312 where  $dN$  is the expectation value of the number of spontaneous nuclear transitions  
1313 which take place in the time interval  $dt$ .

1314

1315 The unit of activity is  $s^{-1}$  with the special name becquerel (Bq).

1316

1317

1318 **ambient dose equivalent,  $H^*(d)$**

1319

1320 at a point in a radiation field, is the dose equivalent that would be produced by the  
1321 corresponding expanded and aligned field, in the **ICRU** sphere at a depth,  $d$ , on the  
1322 radius opposing the direction of the aligned field.

1323

1324 Unit:  $J\ kg^{-1}$ . The special name for the unit of ambient dose equivalent is sievert (Sv).

1325

1326

1327 **contamination**

1328

1329 the presence of a radioactive substance on a surface in quantities in excess of  
1330  $0.4\ Bq/cm^2$  for beta and gamma emitters and low toxicity alpha emitters, or  
1331  $0.04\ Bq/cm^2$  for all other alpha emitters.

1332

1333

1334 **directional dose equivalent,  $H'(d,\Omega)$**

1335

1336 at a point in a radiation field, is the dose equivalent that would be produced by the  
1337 corresponding expanded field, in the ICRU sphere at a depth,  $d$ , on a radius in a  
1338 specified direction,  $\Omega$ .

1339

1340 Unit:  $J\ kg^{-1}$ . The special name for the unit of directional dose equivalent is sievert  
1341 (Sv).

1342

1343 A depth  $d=0.07\ mm$  is recommended for weakly penetrating radiation

1344

1345

1346 **effective dose**

1347

1348 the quantity  $E$ , defined as a summation of the tissue equivalent doses, each  
1349 multiplied by the appropriate tissue weighting factor:

1350

$$E = \sum_T w_T \cdot H_T$$

1351

1352

1353

where  $H_T$  is the equivalent dose in tissue T and  
 $w_T$  is the tissue weighting factor for tissue T.

1354 From the definition of equivalent dose, it follows that:

1355 
$$E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

1356 where  $w_R$  is the radiation weighting factor for radiation R and  
1357  $D_{T,R}$  is the average absorbed dose in the organ or tissue T.

1358  
1359 The unit of effective dose is  $J\ kg^{-1}$ , termed the sievert (Sv).

1360

1361

1362 **equivalent dose**

1363

1364 a measure of dose in organs and tissues which takes into account the type of radiation  
1365 involved.

1366

1367 Equivalent dose,  $H$ , is a weighted dose in an organ or tissue, with the radiation  
1368 weighting factor(s) determined by the type and energy of the radiation to which the  
1369 organ or tissue is exposed. The equivalent dose  $H_T$  in organ or tissue T is given by the  
1370 expression:

1371

$$H_T = \sum_T w_R \cdot D_{T,R}$$

1372 where  $D_{T,R}$  is the absorbed dose averaged over the organ or tissue T due to radiation  
1373 R and

1374

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**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.

**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.

1405 **incident**

1406

1407 an event which causes, or has the potential to cause, abnormal exposure of employees  
1408 or of members of the public and which requires investigation of its causes and  
1409 consequences and may require corrective action within the program for control of  
1410 radiation.

1411

1412

1413 **irradiating apparatus**

1414

1415 any apparatus capable of producing ionising radiation of any prescribed type, or  
1416 capable of accelerating atomic particles under any prescribed conditions

1417

1418

1419 **kerma, K**

1420

1421 the quotient of  $dE_{tr}$  by  $dm$ , where  $dE_{tr}$  is the sum of the initial kinetic energies of all  
1422 the charged particles liberated by uncharged particles in a mass  $dm$  of material, thus

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

1423

1424 Unit:  $J\ kg^{-1}$ . The special name for the unit of kerma is gray (Gy).

1425

1426

1427 **NHMRC**

1428

1429 the National Health and Medical Research Council. Its principal function is to advise  
1430 the Australian community on matters relating to the achievement and maintenance  
1431 of high standards of individual and public health through appropriate legislation,  
1432 administration and practices, and to encourage health and medical research to  
1433 achieve those standards.

1434

1435

1436 **radioactive source**

1437

1438 any quantity of radioactive material which is intended for use as a source of ionizing  
1439 radiation.

1440

1441

1442 **radioactive substance**

1443

1444 material that undergoes spontaneous transformation of its nucleus with the emission  
1445 of ionizing radiation and which, for the purposes of this Code, exceeds a prescribed  
1446 concentration or activity as determined by the relevant regulatory authority.

1447

1448

1449 **relevant regulatory authority**

1450

1451 the radiation protection authority or authorities designated, or otherwise recognised,  
1452 for regulatory purposes in connection with protection and safety. A list of radiation  
1453 protection authorities in Australia is included as Annex 1 of this Code.

1454

1455

1456 **Responsible Person**

1457

1458 in relation to any radioactive source, radiation apparatus, prescribed radiation facility  
1459 or premises on which unsealed radioactive sources are stored or used means the  
1460 person:

- 1461 (a) having overall management responsibility including responsibility for the  
1462 security and maintenance of the source, apparatus, or facility;
- 1463 (b) having overall control over who may use the source or apparatus, or  
1464 facility; and
- 1465 (c) in whose name the source, apparatus, or facility, would be registered if  
1466 this is required.

1467

1468

1469 **routine maintenance**

1470

1471 work intended by the manufacturer of the equipment to be performed by the  
1472 Responsible Person.

1473

1474

1475 **source assembly**

1476

1477 the component into which the radiation source(s) are permanently fixed. The source  
1478 assembly may be movable or may itself be permanently fixed.

1479

1480

1481 **supplier**

1482

1483 any legal person to whom a registrant or licensee delegates duties, totally or partially,  
1484 in relation to the design, manufacture, production or construction of a source. (An  
1485 importer of a source is considered a supplier of the source.)

1486

1487

1488 **Annex 1**

1489

1490 **HEALTH EFFECTS OF IONIZING RADIATION AND STANDARDS FOR**  
1491 **CONTROL OF EXPOSURE**

1492

1493 It is well known that high doses of ionizing radiation can cause harm, but there is  
1494 continuing scientific uncertainty about effects at low doses. At levels of dose  
1495 routinely encountered by members of the public and most present-day radiation  
1496 workers, there is little or no epidemiological evidence of health effects. Radiation  
1497 protection standards recognize that it is not possible to eliminate all radiation  
1498 exposure, but they do provide for a system of control to avoid unnecessary exposure  
1499 and to keep doses in the low dose range.

1500

1501 Extreme doses of radiation to the whole body (around 10 sievert\* and above),  
1502 received in a short period, cause so much damage to internal organs and tissues of  
1503 the body that vital systems cease to function and death may result within days or  
1504 weeks. Very high doses (between about 1 sievert and 10 sievert), received in a short  
1505 period, kill large numbers of cells, which can impair the function of vital organs and  
1506 systems. Acute health effects, such as nausea, vomiting, skin and deep tissue burns,  
1507 and impairment of the body's ability to fight infection may result within hours, days  
1508 or weeks. The extent of the damage increases with dose. However, 'deterministic'  
1509 effects such as these are not observed at doses below certain thresholds. By limiting  
1510 doses to levels below the thresholds, deterministic effects can be prevented entirely.

1511

1512 Doses below the thresholds for deterministic effects may cause cellular damage, but  
1513 this does not necessarily lead to harm to the individual: the effects are probabilistic or  
1514 'stochastic' in nature. It is known that doses above about 100 millisievert, received in  
1515 a short period, lead to an increased risk of developing cancer later in life. There is  
1516 good epidemiological evidence – especially from studies of the survivors of the atomic  
1517 bombings - that, for several types of cancer, the risk increases roughly linearly with  
1518 dose, and that the risk factor averaged over all ages and cancer types is about 1 in 100  
1519 for every 100 millisievert of dose (i.e. 1 in 10,000 per millisievert).

1520

1521 At doses below about 100 millisievert, the evidence of harm is not clear-cut. While  
1522 some studies indicate evidence of radiation-induced effects, epidemiological research  
1523 has been unable to establish unequivocally that there are effects of statistical  
1524 significance at doses below a few tens of millisieverts. Nevertheless, given that no  
1525 threshold for stochastic effects has been demonstrated, and in order to be cautious in  
1526 establishing health standards, the proportionality between risk and dose observed at  
1527 higher doses is presumed to continue through all lower levels of dose to zero. This is  
1528 called the linear, no-threshold (LNT) hypothesis and it is made for radiation  
1529 protection purposes only.

1530

1531 There is evidence that a dose accumulated over a long period carries less risk than the  
1532 same dose received over a short period. Except for incidents and medical exposures,  
1533 doses are not normally received over short periods, so that it is appropriate in  
1534 determining standards for the control of exposure to use a risk factor that takes this  
1535 into account. While not well quantified, a reduction of the high-dose risk factor by a  
1536 factor of two has been adopted internationally, so that for radiation protection  
1537 purposes the risk of radiation-induced fatal cancer (the risk factor) is taken to be  
1538 about 1 in 20,000 per millisievert of dose for the population as a whole.

---

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

1539 If the LNT hypothesis is correct, any dose carries some risk. Therefore, measures for  
 1540 control of exposure for stochastic effects seek to avoid all reasonably avoidable risk.  
 1541 This is called optimising protection. However, risk in this sense may often be  
 1542 assessed in terms of risk to a population, and may not ensure sufficient protection of  
 1543 the individual. Consequently, the optimisation approach is underpinned by applying  
 1544 dose limits that restrict the risk to individuals to an acceptable level. The  
 1545 fundamental regulatory philosophy is expressed in three principles, based on the  
 1546 recommendations of the International Commission on Radiological Protection  
 1547 (**ICRP**), which may be summarised as follows:

1548  
 1549 *Justification:* human activities that cause exposure to radiation may be  
 1550 permitted only if they do more good than harm;

1551  
 1552 *Optimisation of protection:* exposure to radiation from justified activities should  
 1553 be kept as low as reasonably achievable, social and economic factors being taken  
 1554 into account; and

1555  
 1556 *Limitation of individual dose:* doses must not exceed the prescribed dose limits.

1557  
 1558 Determining what is an acceptable risk for regulatory purposes is a complex value  
 1559 judgement. The ICRP reviewed a number of factors in developing its  
 1560 recommendations, which have in general been internationally endorsed, including by  
 1561 the World Health Organization, the International Labour Organisation and the  
 1562 International Atomic Energy Agency. Australia's Radiation Health Committee, now  
 1563 established under the ARPANS Act<sup>†</sup>, has recommended that the international  
 1564 standards be adopted in Australia. The recommended dose limits are summarised as  
 1565 follows:

1566  
 1567

<b>Limit on effective dose*</b>		
	For occupational exposure	For members of the public
1568		
1569		
1570		
1571	To limit individual risk	20 mSv per year, averaged over 5 years*
1572		1 mSv in a year*

1573  
 1574 \*for details, see ARPANSA's *Recommendations for limiting exposure to ionizing radiation*  
 1575 (2002)

1576  
 1577 In most situations, the requirements for limiting individual risk ensure that doses are  
 1578 below deterministic thresholds, but for cases where this does not apply, the  
 1579 recommended limits are as follows:

---

† The *Australian Radiation Protection and Nuclear Safety Act (1998)*

1580

1581

**Annual limit on equivalent dose\***

1582

1583

For occupational  
exposure

For members of  
the public

1584

1585

To prevent deterministic effects

1586

in the lens of the eye

150 mSv

15 mSv

1587

in the skin

500 mSv

50 mSv

1588

in the hands and feet

500 mSv

–

1589

1590

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

1591

1592

1593

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 should be a reasonable assurance that fetal dose can be kept below 1 mGy<sup>‡</sup> 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).

1594

1595

1596

1597

1598

1599

1600

1601

1602

1603

1604

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

1605 **Annex 2**

1606

1607 **ANCILLARY EQUIPMENT AND DEVICES FOR RADIOGRAPHY**

1608

1609 To position the animal correctly for radiography special devices should be used to  
1610 reduce to an absolute minimum the number of occasions on which it is necessary for  
1611 the animal to be held by hand.

1612

1613 The following devices will be found useful:

1614

1615 ***Small animal radiography***

1616

1617 (a) *Adhesive tape, gauze bandages*

1618 Various types of tape and bandaging may be tied around, or placed over, an  
1619 anatomical region to fix it in position for radiography. They may also be used  
1620 to remove an overlying anatomical region from the area of interest.

1621

1622 (b) *Sand bags*

1623 The sand should be contained in a sealed bag with an outer cover that can be  
1624 removed for cleaning. The bags should be made in a variety of sizes so that  
1625 they can be placed over a limb, or used as a 'prop', to position an area for  
1626 radiography.

1627

1628 (c) *Positioning troughs*

1629 These can be made of timber, perspex, or other sheet or foam plastic material.  
1630 Usually, they are approximately V-shaped and may be constructed with  
1631 adjustable sides. They are particularly useful for maintaining the animal in  
1632 position for ventro-dorsal projections.

1633

1634 (d) *Radiolucent<sup>38</sup> pads*

1635 Radiolucent pads, made from foam plastic or rubber, can be purchased in a  
1636 variety of shapes and sizes and may be used to position the animal correctly.  
1637 Plastic bags filled with cotton wool will serve the same function.

1638

1639 (e) *Cassette holders*

1640 These may be simple devices, such as a welding clamp with a handle that can  
1641 be attached to the cassette. Alternatively they may be of a 'picture-frame'  
1642 design, permitting the cassette to be slipped into a frame, to which a handle is  
1643 attached. Adjustable cassette holders which may be clamped to the edge of  
1644 the examination table are very useful. A wall mounted cassette holder,  
1645 adjustable in the vertical direction, can be used for standing lateral  
1646 radiographs.

1647

1648 (f) *Other devices*

1649 The animal can also be positioned using compression bands (fitted to some  
1650 X-ray tables), mouth gags, and suction cups that can be firmly fastened to the  
1651 table (the cups may hold metal rods or padded metal plates that can be used  
1652 to support the animal). Birds or small mammals may be restrained by placing  
1653 them inside a short length of plastic tubing or piping with suitable ventilation.

---

<sup>38</sup> A material that does not impede passage of X-rays.

1654 ***Large animal radiography***

1655

1656 (a) *Cassette holders*

1657 In radiography of the distal limbs of standing animals, a cassette holder may  
1658 be used that is of a design similar to that described for small animal  
1659 radiography, provided the handle is of sufficient length to ensure that the  
1660 hand and body of the employer are outside the primary X-ray beam.

1661

1662 In radiography of areas of the standing animal, other than the distal limb, the  
1663 cassette should be placed either on a mobile stand that can be positioned  
1664 beside the animal, or in a wall mounted cassette holder.

1665

1666 (b) *Other devices*

1667 Blocks of wood, including blocks for examination of the equine navicular  
1668 bone, will be especially useful in positioning the hoof for radiography. In the  
1669 anaesthetised animal, ropes and hobbles, and metal 'props' should be used to  
1670 assist in positioning an area for radiography.

1671

1672 **Annex 3**

1673

1674 **GUIDE TO MANUAL PROCESSING OF RADIOGRAPHS**

1675

1676 This Guide has been prepared for persons processing radiographic films manually.  
1677 Too great an emphasis cannot be placed on the need for high standards of practice in  
1678 the processing of radiographs. High standards of processing contribute to better  
1679 quality films for diagnostic purposes and to the elimination of one cause of avoidable  
1680 repeat radiographic examinations which result in additional unnecessary radiation  
1681 exposure, both to veterinary staff and assistants.

1682

1683 The quality of a finished radiograph depends upon a number of factors, such as  
1684 radiographic technique, area being examined, patient size, exposure factors, type of  
1685 film (or film-screen combination), accessories such as bucky, grid, and of course  
1686 processing. To produce high quality films it is of the utmost importance that as many  
1687 of these factors as possible be standardised. Although animals will vary a great deal  
1688 and exposure will have to vary to compensate, *all* processing factors should be  
1689 constant.

1690

1691 To obtain radiographs of a uniformly high quality it is important that exposed films  
1692 be processed under reproducible conditions with respect to:

- 1693 (a) concentration of chemical components;  
1694 (b) temperature of solution;  
1695 (c) time of development; and  
1696 (d) development techniques.

1697

1698 With respect to the time-temperature relationship, the use of a fixed temperature and  
1699 a fixed time of development is strongly recommended. If a fixed temperature is not  
1700 achieved, it is important that the temperature of the developing solution be measured  
1701 and a time of development employed appropriate to that temperature. This is  
1702 calculated from a time-temperature chart.

1703

1704 The optimum quality with respect to detail and contrast of a radiograph cannot be  
1705 achieved without proper processing. Unsatisfactory processing of an exposed film  
1706 will result in a radiograph of less than optimal quality which may result in either an  
1707 incorrect diagnosis or an unnecessary repeat exposure. Incorrect exposure technique  
1708 in radiography should not be compensated for by adjusting processing procedures.  
1709 Adjusting processing procedures in an attempt to correct for over-exposure of a  
1710 radiograph can lead to persistent errors in exposure techniques. A film which has  
1711 been over-exposed and under-developed will not only be of less than optimal quality  
1712 but will have been obtained with the staff having received more radiation than  
1713 necessary.

1714

1715 Attention should be directed towards:

- 1716 (e) The organisation of the work in the darkroom to avoid damage to films.  
1717 (f) The use of appropriate safe-lights for the type of film being used and testing  
1718 the safe-lights for film fogging.  
1719 (g) The proper storage of unexposed film away from heat, radiation and chemical  
1720 contamination.

- 1721 (h) The use of film on a first-in, first-out basis to minimise the use of old stock.  
 1722 (i) The regular replenishment of processing solutions.  
 1723 (j) Following the procedures outlined below with respect to developing, fixing,  
 1724 washing and drying of films.

1725  
 1726 Ideally, the following facilities should be available:

- 1727  
 1728 **Light-proof darkroom:** Exclude all white light.  
 1729  
 1730 **Processing unit:** Developer, rinse, fixer, wash tanks.  
 1731  
 1732 **Drying cabinet:** Variable heat control, timer, racks.  
 1733  
 1734 **Safe-Lights:** As recommended by the film manufacturer.  
 1735  
 1736 **Thermometer:** Not mercury.  
 1737  
 1738 **Developer heater:** For example, an adjustable temperature tropical  
 1739 aquarium heater. This should be used in  
 1740 conjunction with a core balance leakage circuit  
 1741 breaker to minimise the risk of electric shock.  
 1742  
 1743 **Timer:** Simple 60 minute timer with alarm.  
 1744  
 1745 **Film hangers:** Tension type to fit all film sizes and tanks.  
 1746  
 1747 **Adequate plumbing:** Hot and cold running water.  
 1748  
 1749 **Adequate drainage**  
 1750  
 1751 **Chemicals:** Developer, fixer, developer replenisher, wetting  
 1752 agent. Mix to manufacturer's instructions.  
 1753  
 1754 **Chemical stirring rods:** 2 PVC or stainless steel rods. Use one for  
 1755 developer and one for fixer. Do not interchange.  
 1756  
 1757 **Workbench:** Flat smooth surface for film and cassette  
 1758 handling.  
 1759  
 1760 **Adequate film storage**  
 1761  
 1762 (a) Away from radiation;  
 1763 (b) No temperature excesses;  
 1764 (c) Dry area; and  
 1765 (d) Store on edge in light-proof containers – resealable, or a film hopper.

1766  
 1767 **Processing Guide:**  
 1768

- 1769 1. Remove the film from the cassette and then write (with pencil) or print, using  
 1770 actinic marker, the patient and owner's name and the date on the film.  
 1771

- 1772 2. Attach the film to the correct size hanger – clipping the lower edge first.  
1773  
1774 3. Check developer temperature, set the timer for the recommended time, and  
1775 place the film in the developer.  
1776  
1777 4. Agitate the film using a vertical motion when first placed in the tank and 3 or  
1778 4 times during the developing period. Attempt to do this without lifting film  
1779 out of the solution.  
1780  
1781 5. When the timer rings, quickly remove the film and allow it to drain over the  
1782 rinse tank NOT over the developer.  
1783  
1784 6. Rinse the film for 15 seconds in rinse tank and clean running water and then  
1785 drain back into the rinse tank.  
1786  
1787 7. Place the film in the fixer tank and again agitate a number of times -  
1788 particularly during the first minute of fixing.  
1789  
1790 8. Leave the film in the fixer for at least twice the time it takes to clear the  
1791 unexposed sections (normally 4-6 minutes in all). The film should not be left  
1792 in the fixer for more than 15 minutes.  
1793  
1794 9. Allow the fixer to drain back into the fixer tank and then place the film in  
1795 clean running water for 30 minutes. Make sure there is space between each  
1796 film and that the entire hanger is covered during washing.  
1797  
1798 10. After the 30 minutes, briefly rinse the film in a small tank of water containing  
1799 a wetting agent solution. Drain the films and hang to dry – warm moving air  
1800 is most effective.

1801  
1802 NOTE: Steps 1 - 8 must carried out under a safe-light.  
1803

#### 1804 **Additional Processing Hints**

- 1805  
1806 (a) Keep hands dry when handling films.  
1807 (b) Avoid splashing chemicals (causes contamination).  
1808 (c) Replenish tanks regularly.  
1809 (d) Cover tanks with lids when not in use – retards oxidation of the developer and  
1810 keeps dust from all solutions.  
1811 (e) Ensure that films do not touch each other, other hangers or the sides of the  
1812 tanks during processing.  
1813 (f) Most importantly, keep the darkroom CLEAN AND TIDY.  
1814 (g) Always stir developer with Developer Stick and fixer with Fixer Stick before  
1815 processing.  
1816 (h) Load and unload cassettes as far away from wet solution tanks as is practical  
1817 to avoid marking films and staining intensifying screens.  
1818

1819	<b>Care of the Chemistry</b>	
1820		
1821	<b>Developer</b>	
1822		
1823	<i>Temperature</i>	20° - 24°C is the usual range.
1824		
1825	<i>Development Time</i>	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.
1826		
1827		
1828		
1829	<i>Stir</i>	Before using, with a 'Developer Only' stirrer.
1830		
1831	<i>Replenish</i>	Low level must 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).
1832		
1833		
1834		
1835		
1836	<i>Replace</i>	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).
1837		
1838		
1839		
1840	<i>Mixing</i>	Check the volume of the tank and mix strictly to manufacturer's recommendations. Always mix developer <i>after</i> fixer. Contamination of developer is a greater problem.
1841		
1842		
1843		
1844	<b>Rinse</b>	
1845		
1846	<i>Temperature</i>	As for developer.
1847		
1848	<i>Time</i>	15 seconds.
1849		
1850	<i>Water</i>	Must be clean and running – at least 8 changes per hour.
1851		
1852	<b>Fixer</b>	
1853		
1854	<i>Temperature</i>	As for <b>developer</b> .
1855		
1856	<i>Time</i>	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.
1857		
1858		
1859		
1860		
1861	<i>Stir</i>	Before using, with a 'Fixer Only' stirrer.
1862		
1863	<i>Replenish</i>	When the clearing time is greater than 2½ minutes, remove 5 litres from the tank and replace with 5 litres of freshly mixed replenisher.
1864		
1865		
1866		
1867	<i>Replace</i>	When clearing time is over 3 minutes or at least every 6 months.
1868		
1869		
1870	<i>Mixing</i>	Check the volume of the tank and mix strictly to the manufacturer's instructions. Always mix fixer before developer.
1871		
1872		

1873		
1874	<b>Wash</b>	
1875		
1876	<i>Temperature</i>	As for developer.
1877		
1878	<i>Time</i>	30 minutes.
1879		
1880	<i>Water</i>	Must be clean (fit to drink) and running – at least 8 changes per hour.
1881		
1882		
1883		
1884		

1885 **NOTE:**

1886  
1887 All solutions should be approximately the same temperature, though only the  
1888 developer is critical.

1889  
1890 When solutions are changed, the tanks should be thoroughly cleaned – a hard plastic  
1891 scourer, not likely to scratch the surface, should be used (steel wool and abrasive  
1892 powders should not be used).

1893  
1894 To stop algae build-up in the rinse and wash tanks, they should be drained each  
1895 night, cleaned and allowed to dry overnight.

1896  
1897 Viewing boxes should not be placed above processing tanks as splashing of fixer into  
1898 developer must be avoided.

1899  
1900 **To Calculate Volume of Tanks**

1901  
1902 Fill empty tank with water from a measured container (e.g. 2 litre jug) and record  
1903 volume;

1904  
1905 OR

1906  
1907 Measure internal dimensions in centimetres and substitute in the equation:

1908  
1909 
$$\text{Volume (in litres)} = \frac{\text{Depth} \times \text{Width} \times \text{Length}}{1000}$$

1910  
1911 **To Test Light-Proofness of Darkroom**

1912  
1913 Turn off all darkroom lights and remain in the completely darkened room for 10  
1914 minutes. Look around the room for tiny spots of light and mark them with chalk.  
1915 Repair holes or patch them with black electrical tape.

1916  
1917 **To Test Safeness of Safe-lights**

- 1918  
1919 1. Physically examine filter and housing for cracks or white light leaks. Check  
1920 that globe is 25 watts or less (preferably 15 watts).  
1921  
1922 2. In total darkness load sheet of X-ray film into cassette; expose cassette to  
1923 50 kVp at a focus film distance of 1.0 m and preferably in the range of  
1924 1-4 mAs.  
1925

- 1926 3. Turn off all darkroom lights, remove film from cassette and place film on  
1927 bench top.  
1928  
1929 4. Cover one half of the film with a piece of cardboard.  
1930  
1931 5. With a second piece of cardboard cover all but 2 cm of the film.  
1932  
1933 6. Turn the safe-light on. Every 30 seconds move the second piece of cardboard  
1934 so that it exposes an additional 2 cm of film to the safe-light.  
1935  
1936 7. Turn off the safe-light at the end of the last 30 second period and process the  
1937 film in total darkness.  
1938  
1939 8. Safe-lights can only be considered safe for a period of exposure corresponding  
1940 to the area which shows no significant difference in blackness from the area  
1941 exposed only to radiation.  
1942  
1943 9. If your handling time in the darkroom is longer than the safe period (see 8)-  
1944 • replace globe with lower wattage and/or  
1945 • direct safe-light at the wall or ceiling and/or  
1946 • replace filter according to film manufacturer's recommendations and  
1947 always -  
1948 • retest

1949

#### **Further Information**

1950

1951 All film and chemical manufacturers will supply, free of charge, excellent publications  
1952 which explain image formation, darkroom practice, care of films and similar topics.  
1953 Ask your supplier.  
1954  
1955

1956 **Annex 4**

1957

1958 **RADIATION WARNING LABELS AND NOTICES**

1959

1960 Radiation warning signs and notices, must 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.

1961

1962

1963

1964

1965

1966

A4.1 Colours for radiation warning labels and notices

1967

Background: yellow

1968

Marking and trefoil: black

1969



1970

1971

1972

[NOTE: Additional warning labels will be added to this Annex.]

1973

1974

1975 **Annex 5**

1976

1977 **STRONTIUM-90 APPLICATORS**

1978

1979 **Description of applicator**

1980

1981 Strontium-90 is a radioactive element with a **half-life** of approximately 28 years. In  
1982 equilibrium with its decay product yttrium-90, beta radiation is emitted which has  
1983 energy suitable for the treatment of very thin lesions.

1984

1985 The strontium-90 in an insoluble form is incorporated in a rolled silver disc, which is  
1986 embedded into a recess in a slightly larger metal disc. The strontium-90 disc is then  
1987 covered by a thin protective metal foil window. The strontium-90 applicator or plate  
1988 is thus a disc with an 'active' front face made as thin as possible to enable as many as  
1989 possible of the beta particles to be emitted with minimal loss of energy, but adequate  
1990 to prevent damage or loss of the strontium-90. This window is very delicate and  
1991 must be treated with great care. There is an inactive border or margin 2-3 mm wide  
1992 surrounding the active area. The 'inactive' back of the plate is thick enough to absorb  
1993 the beta particles. A boss or lug to which a handle may be attached, is secured to the  
1994 back of the plate. Although beta radiation is emitted only from the front face of the  
1995 plate, X-radiation is produced in all directions by interaction of beta particles with  
1996 the metal of the device and also from surrounding materials. In addition, beta  
1997 particles emitted from the front face may be back scattered from nearby materials.

1998

1999 Strontium-90 applicators are usually made as flat plates but some are fabricated into  
2000 special shapes for particular purposes, such as for treatment of the eye. Normally the  
2001 strontium-90 is uniformly distributed over the surface of the plate but for some  
2002 specialised requirements an asymmetrical distribution may be used.

2003

2004 The dose rates from strontium-90 applicators vary considerably depending on the  
2005 initial radioactive content and on the thickness of the window material, but may be  
2006 very high. Improper use may be injurious to the user and patients. Nominally  
2007 identical plates may have significantly different dose-rates. It is not possible to  
2008 calculate the dose-rates of strontium-90 applicators from a knowledge of radioactive  
2009 content. The dose-rate at the surface of the plate is usually specified as the surface  
2010 dose-rate in tissue-equivalent material over the central area of the source. A  
2011 Certificate of Measurement should accompany a new applicator when it is purchased.  
2012 If there is no documentary evidence of the dose-rate then it must be measured by an  
2013 accredited service. The dose rate is expressed in units of gray per second (or rad per  
2014 second, 1 gray = 100 rad). The treatment time is calculated by dividing the desired  
2015 surface dose by the dose-rate. In clinical applications, correct delivery of the  
2016 prescribed dose is important and so it is necessary to use a stopwatch to measure the  
2017 treatment time.

2018

2019 Some applicators are supplied with a 'cut-out mask' which may be fitted over the  
2020 active face of the applicator to reduce the area to be treated. The use of the mask will  
2021 reduce the surface dose rate to a considerable extent and a separate determination of  
2022 the dose rate is required for use of the applicators when the mask is in place.

2023

2024 As the strontium-90 decays with its half-life of approximately 28 years the dose-rate  
2025 from an applicator is reduced accordingly and thus the time to administer a given  
2026 dose must be increased. The dose-rate should be re-determined at intervals not  
2027 exceeding two years.

2028

2029 As the beta radiation penetrates through soft tissues the dose delivered diminishes  
2030 relative to that at the surface. The following table indicates the dose at a depth as a  
2031 percentage of the surface dose:

2032		
2033	0.0 mm	100%
2034	1.0 mm	65%
2035	1.5 mm	50%
2036	2.0 mm	35%
2037	2.5 mm	25%

2038  
2039 From consideration of this depth-dose effect it is evident that the use of strontium-90  
2040 applicators is limited to the treatment of very superficial and thin lesions, typically  
2041 those on the surface of the eye or very thin non-invasive lesions on the skin. It is not  
2042 good clinical practice to attempt treatment of tissues situated more than 2 mm from  
2043 the active surface of a strontium-90 applicator.

2044  
2045 Strontium-90 applicators are very delicate devices and any mishandling, dropping,  
2046 scratching, corrosion or other damage could cause a dangerous leakage of radioactive  
2047 material. Strontium applicators must be checked for radioactive leakage using an  
2048 immersion test (as described in a recommended Standards publication), at regular  
2049 intervals, not exceeding one year. It is important to note that:

2050 (a) although the range of beta particles in tissue is only a few millimetres, the  
2051 range in air is a few metres,

2052 (b) the dose-rate is quite high and an applicator may be capable of delivering a  
2053 therapeutic dose in less than one minute.

2054  
2055 A statement of the current surface dose-rate for the particular strontium-90  
2056 applicator and a table of times for commonly used doses should always accompany  
2057 the applicator in its storage box. In addition, a copy of the following notes 'Handling  
2058 and Care of Strontium-90 Applicators or Plates' should be included.

### 2059 2060 **Storage and transport of strontium-90 applicators**

2061  
2062 Some manufacturers supply strontium applicators in a specially designed box  
2063 containing a support system and integral aluminium and lead shielding. In some  
2064 cases, applicators are supplied in lead containers or pots which are not satisfactory as  
2065 storage containers. In addition, the applicators are often wrapped in cotton wool,  
2066 gauze or foam plastic. This material degrades from the effects of radiation and leaves  
2067 a sticky deposit that may adhere to the delicate active surface of the applicator.

2068  
2069 A container should be used in which the beta particles are absorbed firstly in a  
2070 material of low atomic number e.g. aluminium, before using lead as a radiation  
2071 shield. Beta particles absorbed directly in lead give rise to more secondary X-  
2072 radiation of higher energy than in the case of absorption in aluminium.

2073  
2074 A suitable container consists of an inner section of aluminium of at least 5 mm  
2075 thickness. Materials such as wood (masonite), silicones, perspex etc. are unsuitable  
2076 as they degrade under beta radiation and may cause damage to the active face of the  
2077 applicator. The outer shield of the container should be at least 3 mm of lead.

2078  
2079 The plate should be securely held in place so that the delicate active window is not in  
2080 contact with any material. This may be achieved either by suspending the plate by  
2081 the handle or by supporting it on an annular ring or ledge which makes contact only

2082 with the inactive border of the front face. (A neoprene 'O-ring' of appropriate size is  
2083 quite suitable).

2084  
2085 Such a container is satisfactory for clinical use but it may not be adequate for  
2086 transport unless it is housed in or integral with an outer container or transport box.

2087  
2088 A type of outer container suggested is a lockable metal 'deed' or 'cash' box in which  
2089 the shielded container described above can be held firmly in a central location by a  
2090 block of material such as foam plastic.

2091  
2092 Clause 4.4.3 of the Code requires that the outside of the box carry:

- 2093 (a) the appropriate radiation warning symbol;  
2094 (b) the name of the radioactive element (strontium-90);  
2095 (c) the nominal activity;  
2096 (d) the date of measurement; and  
2097 (e) the owners name, address and contact telephone number.

2098  
2099 The box may also house accessories used in treatment such as handles, forceps,  
2100 stopwatch, dose data tables, handling notes, etc.

2101  
2102 The box should be stored at least two metres away from any commonly occupied  
2103 work area and from any undeveloped film. The storage area should be a locked  
2104 cabinet or safe with the appropriate warning sign and wording as required by the  
2105 relevant regulatory authority.

2106  
2107 If the applicator is to be transported in a vehicle special precautions are necessary. It  
2108 is easy to visualize situations where, as a result of a motor vehicle accident or theft,  
2109 applicators could be handled by unsuspecting persons for extended periods, during  
2110 which significantly hazardous exposures might occur.

2111  
2112 The box should be located as far as possible from the occupants of the vehicle and  
2113 secured in position. The transport arrangements are to be in accordance with the  
2114 requirements of the relevant regulatory authority.

2115  
2116 The loss of an applicator is to be reported to the relevant regulatory authority as soon  
2117 as possible (Clause 4.4.4).

## 2118 2119 **Handling and care of strontium-90 applicators or plates**

2120  
2121 1. A strontium plate emits very energetic beta particles from the front face of the  
2122 plate. Personnel handling plates should take care to minimise their exposure  
2123 to radiation.

2124  
2125 2. No significant beta radiation issues from the back of the plate although there  
2126 is some X-radiation emitted in all directions.

2127  
2128 3. The plate is a delicate structure - any undue force applied to it may cause the  
2129 boss or lug to break away from the active section.

2130  
2131 4. The plate should always be held with its active face away from one's person  
2132 and in such a way that the face is not directed towards anyone else (except in  
2133 its treatment role).

2134

- 2135 5. If it is necessary to examine the active face of the plate during cleaning, it may  
2136 be viewed using a non-metallic mirror.  
2137
- 2138 6. The material of the active face of the plate is very delicate and it should not be  
2139 scratched or abraded.  
2140
- 2141 7. Sterilisation or asepsis may be achieved by immersion in a non-corrosive,  
2142 non-sticky sterilising solution such as chlorhexidene ('Hibitane').  
2143 Glutaldehyde ('Cidex') may be used but this is mildly corrosive and somewhat  
2144 toxic. The sterilising solution should then be thoroughly washed away with  
2145 sterile water.  
2146
- 2147 8. During cleaning great care should be taken not to expose the fingers or any  
2148 other part of the body to the direct radiation from the plate.  
2149
- 2150 9. The plate should be cleaned immediately after use in order to avoid biological  
2151 matter drying and adhering to it. A thin film of dried material on the plate  
2152 surface can significantly reduce the surface dose rate.  
2153
- 2154 10. If the plate is the type which has a cut-out mask fitted then this mask should  
2155 be removed and cleaned separately.  
2156
- 2157 11. The plate should be cleaned by gently wiping with a swab or gauze moistened  
2158 with distilled water. The swab or gauze should be placed on a flat surface and  
2159 the plate wiped on it to avoid irradiating the fingers. (The plate should be  
2160 kept at arms' length as much as possible.) If further cleaning is required then  
2161 a mild detergent or ethanol may be used. Acid solutions should not be used.  
2162
- 2163 12. After cleaning, the plate should be completely dry before being replaced in its  
2164 special container. Saline or sterilising solutions may cause corrosion to the  
2165 container and damage to the plate.  
2166

2167 **Annex 6**

2168

2169 **LASER SAFETY**

2170

2171 **Introduction**

2172

2173 There is an increasingly widespread use of lasers for various applications in  
2174 veterinary science.

2175

2176 Lasers do not emit ionizing radiation but laser radiation is potentially hazardous to  
2177 operators and to persons viewing the direct light beam or its reflections.

2178

2179 Many lasers are capable of inflicting biological damage, mainly burns, with the eye  
2180 and skin being most susceptible to laser injury.

2181

2182 The possession and use of certain lasers may be subject to control by the relevant  
2183 regulatory authority and individual users may be required to hold a licence.

2184

2185 **Description**

2186

2187 Lasers differ from all other sources of light both in the mechanism of operation and  
2188 in the quality of the light produced. Lasers emit light either continuously (continuous  
2189 wave or cw lasers) or in pulses. This light is generally either monochromatic or  
2190 consists of a number of specific wavelengths within a beam of low divergence, i.e. well  
2191 collimated and high power density (irradiance) often many times brighter than the  
2192 sun. As an example a low powered (5 mW) gas laser can have an apparent brightness  
2193 (radiance) 1000 times greater than the sun. Laser wavelengths range from the  
2194 ultraviolet through the visible to the far infrared regions of the spectrum.

2195

2196 **Hazards**

2197

2198 Lasers that produce radiation in the visible and near infrared regions of the spectrum  
2199 are particularly hazardous to the eye. This is because the eye will focus the laser  
2200 beam on to the retina and a retinal burn may result in much the same way as a  
2201 magnifying glass using the sun's rays can burn a hole in paper. The power density of  
2202 the laser beam image formed on the retina is typically of the order of 100 000 times  
2203 the power density of the laser beam at the cornea.

2204

2205 A retinal burn or lesion may result in serious and permanent impairment of vision or  
2206 even blindness in the eye affected. A visual decrement resulting from a small lesion  
2207 will usually be noted subjectively by an exposed individual only when the central  
2208 region of the retina is involved. The damage appears initially as a blurred white spot  
2209 obscuring the central area of vision but within two or more weeks it changes to a  
2210 black spot. Ultimately the victim may cease to be aware of this blind spot during  
2211 normal vision. However, it can be revealed immediately in looking at an empty visual  
2212 scene such as a blank sheet of white paper. Lesions occurring in the peripheral field  
2213 of vision will be registered subjectively only when gross retinal damage has occurred.  
2214 Small peripheral lesions may pass unnoticed and may not even be detected during a  
2215 systematic eye examination.

2216

2217 The exposure time required to produce a serious lesion depends on many factors, but  
2218 for many lasers exposure times of a fraction of a second can produce such a lesion

2219 and for such lasers, the blink reflex cannot therefore be relied upon to provide  
2220 protection.

2221

2222 For most laser wavelengths, biological damage occurs principally through the heat  
2223 generated by the interaction of light with matter. Ultraviolet radiation will interact  
2224 directly with organic molecules to cause cell damage in addition to the heat  
2225 mechanism of damage. Very high power lasers may also produce a thermally induced  
2226 sonic shock wave that may damage tissue some distances from the site of beam  
2227 exposure by physical displacement of the tissue.

2228

2229 In addition to the hazards of exposure to the direct laser beam, exposure to its  
2230 specular reflections caused by smooth reflecting surfaces, such as mirrors and lenses,  
2231 is often hazardous, depending upon the amount of electromagnetic energy reflected.  
2232 Diffuse reflections may also be hazardous when the reflected electromagnetic energy  
2233 is sufficiently intense.

2234

### 2235 **Protection**

2236

2237 The potential hazards of lasers are outlined in Australian/New Zealand Standard  
2238 AS/NZS 2211.1:1997 'Laser Safety Part 1: Equipment classification, requirements and  
2239 user's guide'. This Standard also details the precautions to be taken by employers  
2240 and gives permissible limits of exposure to laser radiations.

2241

2242 Additional reference should also be made to Australia/New Zealand Standard  
2243 AS/NZS 3200.2.22:1993 'Approval and test specification - Medical electric  
2244 equipment Part 2.22 - Diagnostic and therapeutic laser equipment' and to  
2245 Australia/New Zealand Standard AS/NZS 4173:1994 'Guide to the safe use of lasers  
2246 in health care'.

2247

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## Annex 7

### REGULATORY AUTHORITIES

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

COMMONWEALTH, STATE / TERRITORY	CONTACT
Commonwealth	Director, Regulatory Branch ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au Tel: (02) 9541 8333 Fax: (02) 9541 8348
Australian Capital Territory	Manager Radiation Safety Radiation Safety Section ACT Health Locked Bag 5 Weston Creek ACT 2611 Email: radiation.safety@act.gov.au Tel: (02) 6207 6946 Fax: (02) 6207 6966
New South Wales	Director Radiation Control Department of Environment and Conservation PO Box A290 Sydney South NSW 1232 Email: radiation@epa.nsw.gov.au Tel: (02) 9995 5000 Fax: (02) 9995 6603
Northern Territory	Manager Radiation Protection Radiation Protection Section Department of Health and Community Services GPO Box 40596 Casuarina NT 0811 Email: envirohealth@nt.gov.au Tel: (08) 8922 7152 Fax: (08) 8922 7334
Queensland	Director, Radiation Health Department of Health 450 Gregory Terrace Fortitude Valley QLD 4006 Email: radiation_health@health.qld.gov.au Tel: (07) 3406 8000 Fax: (07) 3406 8030
South Australia	Director, Radiation Protection Division Environment Protection Authority PO Box 721 Kent Town SA 5071 Email: radiationprotection@state.sa.gov.au Tel: (08) 8130 0700 Fax: (08) 8130 0777
Tasmania	Senior Health Physicist Health Physics Branch Department of Health and Human Services GPO Box 125B Hobart TAS 7001 Email: health.physics@dhhs.tas.gov.au Tel: (03) 6222 7256 Fax: (03) 6222 7257
Victoria	Manager, Radiation Safety Program Department of Human Services GPO Box 4057 Melbourne VIC 3001 Email: radiation.safety@dhs.vic.gov.au Tel: (03) 9637 4167 Fax: (03) 9637 4508
Western Australia	Secretary, Radiological Council Locked Bag 2006 Nedlands WA 6009 Email: radiation.health@health.wa.gov.au Tel: (08) 9346 2260 Fax: (08) 9381 1423

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2258  
2259  
2260

**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](http://www.arpansa.gov.au)). For after hours emergencies only, the police will provide the appropriate emergency contact number.

2261 **Annex 8**

2262

2263 **ARPANSA RADIATION PROTECTION SERIES PUBLICATIONS**

2264

2265 ARPANSA has taken over responsibility for the administration of the former NHMRC  
2266 Radiation Health Series of publications and for the codes developed under the  
2267 *Environment Protection (Nuclear Codes) Act 1978*. The publications are being  
2268 progressively reviewed and republished as part of the *Radiation Protection Series*.  
2269 All publications listed below are available in electronic format, and can be  
2270 downloaded free of charge by visiting ARPANSA's website at  
2271 [www.arpansa.gov.au/codes.htm](http://www.arpansa.gov.au/codes.htm).

2272 Radiation Protection Series publications are available for purchase directly from  
2273 ARPANSA. Further information can be obtained by telephoning ARPANSA on  
2274 1800 022 333 (freecall within Australia) or (03) 9433 2211.

2275 **RADIATION PROTECTION SERIES**

2276 RPS 1. Recommendations for Limiting Exposure to Ionizing Radiation (1995) and  
2277 National Standard for Limiting Occupational Exposure to Ionizing  
2278 Radiation (republished 2002)

2279 RPS 2. Code of Practice for the Safe Transport of Radioactive Material (2001)

2280 RPS 3. Radiation Protection Standard for Maximum Exposure Levels to  
2281 Radiofrequency Fields – 3 kHz to 300 GHz (2002)

2282 RPS 4. Recommendations on the Discharge of Patients undergoing Treatment  
2283 with Radioactive Substances (2002)

2284 RPS 5. Code of Practice and Safety Guide for Portable Density/Moisture Gauges  
2285 Containing Radioactive Sources (2004)

2286 RPS 6. National Directory for Radiation Protection, Edition 1.0 (2004)

2287 RPS 7. Recommendations for Intervention in Emergency Situations Involving  
2288 Radiation Exposure (2004)

2289 RPS #. Code of Practice for Safe Use of Radiation in Veterinary Science (200#)

2290 Current publications from the NHMRC Radiation Health Series and the Environment  
2291 Protection (Nuclear Codes) Act Series are available free of charge by contacting  
2292 ARPANSA on (03) 9433 2211 or email [secretariat@arpansa.gov.au](mailto:secretariat@arpansa.gov.au). Publications  
2293 that are still current are:

2294 **RADIATION HEALTH SERIES**

2295

2296 RHS 2. Code of practice for the design of laboratories using radioactive substances  
2297 for medical purposes (1980)

2298 RHS 4. Code of practice for the safe use of radiation gauges (1982)

2299 RHS 8. Code of nursing practice for staff exposed to ionizing radiation (1984)

2300 RHS 9. Code of practice for protection against ionizing radiation emitted from  
2301 X-ray analysis equipment (1984)

2302 RHS 12. Administration of ionizing radiation to human subjects in medical research  
2303 (1984)

2304 RHS 13. Code of practice for the disposal of radioactive wastes by the user (1985)

- 2305 RHS 14. Recommendations for minimising radiological hazards to patients (1985)
- 2306 RHS 15. Code of practice for the safe use of microwave diathermy units (1985)
- 2307 RHS 16. Code of practice for the safe use of short wave (radiofrequency) diathermy  
2308 units (1985)
- 2309 RHS 18. Code of practice for the safe handling of corpses containing radioactive  
2310 materials (1986)
- 2311 RHS 19. Code of practice for the safe use of ionizing radiation in secondary schools  
2312 (1986)
- 2313 RHS 20. Code of practice for radiation protection in dentistry (1987)
- 2314 RHS 21. Revised statement on cabinet X-ray equipment for examination of letters,  
2315 packages, baggage, freight and other articles for security, quality control  
2316 and other purposes (1987)
- 2317 RHS 22. Statement on enclosed X-ray equipment for special applications (1987)
- 2318 RHS 23. Code of practice for the control and safe handling of radioactive sources  
2319 used for therapeutic purposes (1988)
- 2320 RHS 24. Code of practice for the design and safe operation of non-medical  
2321 irradiation facilities (1988)
- 2322 RHS 25. Recommendations for ionization chamber smoke detectors for commercial  
2323 and industrial fire protection systems (1988)
- 2324 RHS 28. Code of practice for the safe use of sealed radioactive sources in borehole  
2325 logging (1989)
- 2326 RHS 29. Occupational standard for exposure to ultraviolet radiation (1989)
- 2327 RHS 30. Interim guidelines on limits of exposure to 50/60Hz electric and magnetic  
2328 fields (1989)
- 2329 RHS 31. Code of practice for the safe use of industrial radiography equipment  
2330 (1989)
- 2331 RHS 34. Safety guidelines for magnetic resonance diagnostic facilities (1991)
- 2332 RHS 35. Code of practice for the near-surface disposal of radioactive waste in  
2333 Australia (1992)
- 2334 RHS 36. Code of practice for the safe use of lasers in schools (1995)
- 2335 RHS 37. Code of practice for the safe use of lasers in the entertainment industry  
2336 (1995)
- 2337 RHS 38. Recommended limits on radioactive contamination on surfaces in  
2338 laboratories (1995)

2339 **ENVIRONMENT PROTECTION (NUCLEAR CODES) ACT SERIES**

2340

2341 Code of Practice on the Management of Radioactive Wastes from the Mining and  
2342 Milling of Radioactive Ores 1982

2343

2344 Code of Practice on Radiation Protection in the Mining and Milling of Radioactive  
2345 Ores 1987

2346

2347

2348

2349 **Contributors to Drafting and Review**

2350

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2367	[To be completed]
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