



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

CODE OF PRACTICE & SAFETY GUIDE

Portable Density/Moisture Gauges Containing Radioactive Sources (2003)

Radiation Protection Series Publication No. ??

Public Comment Version: November 2003

This publication was approved by the Radiation Health Committee on dd mmmm yyyy, and the Radiation Health & Safety Advisory Council, at its meeting on dd mmmm yyyy, advised the CEO to adopt the Code of Practice and Safety Guide.

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. Thus a **Code of Practice** and a corresponding **Safety Guide** may be published within a single set of covers.

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



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

CODE OF PRACTICE & SAFETY GUIDE

Portable Density/Moisture Gauges Containing Radioactive Sources (2003)

Radiation Protection Series Publication No. ??

Public Comment Version: November 2003

This publication was approved by the Radiation Health Committee on dd mmmm yyyy, and the Radiation Health & Safety Advisory Council, at its meeting on dd mmmm yyyy, advised the CEO to adopt the Code of Practice and Safety Guide.

NOTICE

© Commonwealth of Australia [2003]

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without prior written permission from the Commonwealth available from the Department of Finance and Administration. Requests and inquiries concerning reproduction and rights should be addressed to the Manager, Copyright Services, Info Access, GPO Box 1920, Canberra ACT 2601 or by e-mail Cwealthcopyright@finance.gov.au.

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

ISBN ? ??? ????? ?

ISSN 1445-9760

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

1 **Foreword**

2
3 Since the mid 1980s, the basis of regulation for the use of portable density/moisture
4 gauges containing radioactive sources has been the requirements of a Code of Practice
5 produced by the NHMRC. This was the *Code of Practice for the Safe Use of Soil*
6 *Density and Moisture Gauges Containing Radioactive Sources (1984)*.

7
8 Since that time however, there have been significant international advances in
9 radiation protection. The ICRP has revised its radiation protection limits and the IAEA
10 has published two major revisions of its international transport regulations. These
11 changes have been reflected in other Australian Recommendations and Codes of
12 Practice since the promulgation of the 1984 Code of Practice.

13
14 Australia's system of developing radiation protection guidance is now through the
15 Radiation Health Committee, which was established under the *Australian Radiation*
16 *Protection and Nuclear Safety Act 1998*. The Radiation Health Committee has agreed
17 to the development of a Radiation Protection Series of publications, which will be
18 formed by progressively reviewing existing publications in the NHMRC Radiation
19 Health Series and publications formulated under the *Environment Protection (Nuclear*
20 *Codes) Act*, along with consideration of areas for new publications.

21
22 Codes of Practice reflect a regulatory style that should facilitate an easier method of
23 adopting them into the legislation of each Australian jurisdiction. This should result in
24 a greater degree of uniformity of application and interpretation of the requirements of
25 Codes of Practice across all Australian jurisdictions.

26
27 This Code of Practice and Safety Guide has been developed by a working group of the
28 Radiation Health Committee, which has reviewed the 1984 NHMRC Code of Practice
29 with a view to replacing it. The Code establishes requirements for adoption by
30 Commonwealth, State and Territory jurisdictions that will provide a system for the safe
31 use of portable density/moisture gauges containing radioactive sources.

32
33 The main change from the 1984 Code is the requirement for Responsible Persons,
34 suppliers and service providers to develop a radiation protection plan for use by their
35 organisation, thereby generating a safety culture in the workplace. This safety culture
36 will, in turn, give rise to an outcome based radiation protection program.

37
38 Other changes to the Code of Practice and Safety Guide reflect the changes to dose
39 limitation and transport mentioned above.

40
41 The Code was released for a public comment period from 17 November 2003 to
42 19 December 2003 along with a Regulatory Impact Statement, to meet the
43 requirements of the *Principles and Guidelines for National Standard-setting and*
44 *Regulatory Action by Ministerial Councils and Standard-setting Bodies* published by
45 the Council of Australian Governments in November 1997. The comments received
46 were reviewed by the working group, and the final document was approved by the
47 Radiation Health Committee on DD MM 2003, and the Radiation Health and Safety
48 Advisory Council at their meeting of DD MM 2003 advised the CEO to adopt the Code.

DRAFT FOR PUBLIC COMMENT

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

51

52

53

54

55

56

57 [signature]

58

59

60

61 John Loy
62 CEO of ARPANSA

63	Contents	
64		
65	1. Foreword.....	v
66	2. Code of Practice for the Safe Use of Portable Density/ Moisture Gauges Containing Radioactive Sources (2003)	C1
67		
68	3. Safety Guide for the Safe Use of Portable Density/Moisture Gauges Containing Radioactive Sources (2003)	S1
69		
70	4. Index	S22
71	5. Contributors to Drafting and Review	S23
72		

73
74

(This page intentionally left blank)



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

75

76

77

78

79 **CODE OF PRACTICE**

80

81

82

83

**Portable Density/Moisture
Gauges Containing Radioactive
Sources (2003)**

85

86

87

88

89 **Radiation Protection Series Publication No. ??**

90

91

92 **Public Comment Version: November 2003**

93

94

95 This publication was approved by the Radiation Health Committee
96 on dd mmmm yyyy, and the Radiation Health & Safety Advisory Council,
97 at its meeting on dd mmmm yyyy, advised the CEO to adopt the
98 Code of Practice.

99
100
101

(This page intentionally left blank)

102	Contents	
103		
104	1. Introduction.....	C5
105	1.1 CITATION.....	C5
106	1.2 BACKGROUND	C5
107	1.3 PURPOSE	C5
108	1.4 SCOPE	C5
109	1.5 UNITS OF MEASUREMENT	C6
110	2. Radiation Protection Plan	C7
111	3. Responsibilities and Duties	C8
112	3.1 RESPONSIBILITIES OF SUPPLIERS	C8
113	3.2 RESPONSIBILITIES OF THE RESPONSIBLE PERSON.....	C9
114	3.3 RESPONSIBILITIES OF THE SERVICE PROVIDER	C12
115	3.4 RESPONSIBILITIES OF THE EMPLOYEE	C14
116	4. Radiation Monitoring and Radiation Levels	C15
117	4.1 PERSONAL MONITORING DEVICES	C15
118	4.2 SURVEY METERS.....	C15
119	4.3 MANAGEMENT OF AN INCIDENT OR ACCIDENT.....	C16
120	5. Storage and Transport	C17
121	5.1 STORAGE OF GAUGES.....	C17
122	5.2 TRANSPORT OF GAUGES	C18
123	6. Miscellaneous Requirements	C19
124	6.1 REPAIRS AND MAINTENANCE	C19
125	6.2 TRANSFER OF OWNERSHIP	C19
126	6.3 PROHIBITION OF DISPOSAL.....	C20
127	6.4 ACCOUNTABILITY AND RECORDS.....	C20
128	Schedule 1 SOURCE REQUIREMENTS.....	C21
129	1.1 GENERAL RADIOACTIVE SOURCE REQUIREMENTS.....	C21
130	1.2 ENCAPSULATION AND CERTIFICATION OF RADIOACTIVE SOURCES	C21
131	Schedule 2 GAUGE REQUIREMENTS	C22
132	2.1 GENERAL DESIGN REQUIREMENTS OF THE GAUGE.....	C22
133	2.2 SHIELDING REQUIREMENTS.....	C23
134	Schedule 3 SURVEY METERS	C24
135	3.1 GENERAL REQUIREMENTS OF THE SURVEY METER	C24
136	3.2 CALIBRATION OF THE SURVEY METER.....	C24
137	Schedule 4 ARPANSA’S RECOMMENDATIONS FOR LIMITING EXPOSURE	
138	TO IONIZING RADIATION (2002) – DOSE LIMITS.....	C25
139	References	C26
140	Glossary	C27
141	Annex 1 REGULATORY AUTHORITIES.....	C32

142
143
144

(This page intentionally left blank)

145 **1. Introduction**

146
147 **1.1 CITATION**

148
149 This Code of Practice may be cited as the *Code of Practice for Portable*
150 *Density/Moisture Gauges Containing Radioactive Sources (2003)*.

151
152 **1.2 BACKGROUND**

153
154 In Australia, radiation control legislation in all States, Territories and the
155 Commonwealth regulates the radioactive sources used in portable
156 density/moisture gauges. Information on the regulatory authorities that
157 administer the various Acts are provided in Annex 1 of this Code.

158
159 The radioactive sources used in these gauges constitute a significant health
160 hazard unless adequately shielded and handled with proper care.

161
162 The radiation safety legislation of the State, Territory or Commonwealth
163 jurisdiction in which a person is working may require that person to hold a
164 licence. This would need to be confirmed with the relevant regulatory
165 authority for each jurisdiction in which that person is working. Particular
166 consideration will need to be given in the case where a person may need to
167 cross a State/Territory/Commonwealth border or boundary.

168
169 This Code of Practice supersedes the NHMRC *Code of Practice for the Safe*
170 *Use of Soil Density and Moisture Gauges Containing Radioactive Sources*
171 *(1984)*.

172
173 **1.3 PURPOSE**

174
175 The purpose of this Code is to establish working practices, procedures and
176 protective measures that will aid in keeping radiation doses arising from
177 portable density/moisture gauges containing radioactive sources:

- 178 • as low as reasonably achievable, economic and social factors taken into
179 account; and
180 • to ensure that the dose limits (see Schedule 4), specified in the
181 *Recommendations and Standard*, are not exceeded.

182
183 **1.4 SCOPE**

184
185 This Code applies to all self-contained surface, or near-surface, portable
186 density/moisture gauges that incorporate one or more radioactive sources.
187 They are of integral design and include detectors, microprocessor, display
188 components and shielding for gamma radiation. Portable density/moisture
189 gauges containing radioactive sources are capable of in-situ measurement of
190 the density/moisture of soils, sands, asphalts and other similar substances.

191
192 Devices that have a separate probe containing a radioactive source and
193 separate source shielding, and which are designed to measure soil density,

194 moisture or mineralization in bore holes greater than a depth of 10 metres, are
195 not covered in this Code of Practice.

196
197 This Code applies to commercially available portable density/moisture gauges
198 that are required to comply with all of the relevant requirements of this Code.
199 Prototype or research gauges should comply with this Code to the maximum
200 extent possible and should not be constructed or used without special
201 approval from the relevant regulatory authority (see Annex 1).

202
203 This Code may also be applied to other similar portable gauges by the relevant
204 regulatory authority. The relevant regulatory authority should be consulted
205 regarding which sections and clauses of this Code may be applicable to such
206 gauges.

207

208 **1.5 UNITS OF MEASUREMENT**

209

210 In this Code of Practice and Safety Guide, the ICRP 60 protection quantities
211 ‘effective dose’, ‘equivalent dose’, ‘ambient dose equivalent’ and ‘directional
212 dose equivalent’ are used for protection and operational requirements. These
213 quantities are in the units of sievert (Sv). The terms ‘effective dose’,
214 ‘equivalent dose’, ‘ambient dose equivalent’ and ‘directional dose equivalent’
215 have the meanings defined in the glossary and can be practically represented
216 by the ICRU operational quantities (see Quantities and units in radiation
217 protection dosimetry, ICRU Report 51, International Commission on
218 Radiation Units and Measurements, Bethesda, Maryland).

219

220 **2. Radiation Protection Plan**

221

222 2.1 Each Responsible Person, supplier or service provider who deals with a
223 portable density/moisture gauge must ensure that a radiation
224 protection plan is developed, documented, implemented and regularly
225 reviewed to ensure safety in all applicable dealings with the portable
226 density/moisture gauge, including:

- 227 (a) work practices¹;
- 228 (b) roles and responsibilities (Section 3);
- 229 (c) radiation monitoring requirements (Section 4);
- 230 (d) control of an incident or accident involving the gauge
231 (Section 4.3);
- 232 (e) storage of the gauge (Section 5.1);
- 233 (f) transport of the gauge (Section 5.2);
- 234 (g) repairs and maintenance of the gauge (Section 6.1);
- 235 (h) what to do with the gauge (eg. sale, transfer, disposal) when it is
236 no longer required (Sections 6.2 and 6.3);
- 237 (i) records and accountability (Section 6.4); and
- 238 (j) any other requirement that may have a bearing on safety.
- 239

¹ Guidelines for formulating work practices, including working rules and emergency procedures, are given in Section 2 of the Safety Guide for the Safe Use of Portable Density/Moisture Gauges Containing Radioactive Sources (2003).

240 **3. Responsibilities and Duties**

241

242 **3.1 RESPONSIBILITIES OF SUPPLIERS**

243

244 3.1.1 The supplier of a portable density/moisture gauge must ensure that all
245 persons under the supplier's care follow and comply with the radiation
246 protection plan formulated under clause 2.1.1.

247

248 3.1.2 A person must not supply a portable density/moisture gauge that
249 contains one or more radioactive sources unless:

250 (a) that person is licensed in accordance with the requirements of the
251 relevant regulatory authority; and

252 (b) the person to whom the gauge is supplied is licensed in
253 accordance with the requirements of the relevant regulatory
254 authority.

255

256 3.1.3 The supplier of a portable density/moisture gauge must appoint a
257 Radiation Safety Officer where required by the relevant regulatory
258 authority.

259

260 3.1.4 A person who supplies a portable density/moisture gauge must advise
261 the purchaser of their obligations in relation to what to do with the
262 equipment once it has reached the end of its useful life or is no longer
263 required.

264

265 3.1.5 A person must not supply a portable density/moisture gauge that
266 contains one or more radioactive sources unless the type or model of
267 the gauge is approved for use by the relevant regulatory authority.

268

269 3.1.6 In order for the relevant regulatory authority to assess a particular type
270 or model of gauge, the supplier must submit to the relevant regulatory
271 authority:

272 (a) the construction details of the gauge including details of the:

273 (i) source position; and

274 (ii) shielding included in the gauge,

275 (b) details of any test result demonstrating that the gauge complies
276 with the requirements of Schedule 2 of this Code;

277 (c) for each radioactive source to be contained in the gauge, details of
278 the:

279 (i) type of radioactive source;

280 (ii) maximum activity of the radioactive source;

281 (iii) encapsulation details the radioactive source; and

282 (iv) special form certificate for the radioactive source (see
283 Schedule 1 of this Code),

284 (d) the maximum radiation dose rates at distances of 0.05 m and 1 m
285 from the gauge surface when the gauge is loaded with the

- 286 maximum activity of each radioactive source for which the gauge
287 was designed;
- 288 (e) the radiation dose rate profile around the gauge including at
289 locations normally occupied by operators during gauge use;
- 290 (f) such other details as may be required by the relevant regulatory
291 authority to assess compliance with the requirements of this Code.
292
- 293 3.1.7 Prior to the transfer of a portable density/moisture gauge, the supplier
294 must:
- 295 (a) supply the relevant regulatory authority with the name and
296 address of the purchaser or proposed operator;
- 297 (b) ensure that the portable density/moisture gauge is capable of
298 correct and safe operation in accordance with the provisions of
299 this Code; and
- 300 (c) supply to the purchaser or proposed operator all of the relevant
301 information listed in clause 3.1.6 together with operating and
302 maintenance instructions to permit the purchaser or proposed
303 operator to correctly and safely operate the gauge in accordance
304 with the provisions of this Code.
305
- 306 3.1.8 The supplier of a radioactive source must ensure that each radioactive
307 source is:
- 308 (a) or has been, tested to demonstrate compliance with the
309 requirements of Schedule 1 of this Code; and
- 310 (b) accompanied by all relevant certificates².
311
- 312 3.1.9 The supplier of a radioactive source must ensure that copies of all
313 relevant certificates are:
- 314 (a) provided to the Responsible Person at the time that the device is
315 delivered to the Responsible Person; and
- 316 (b) submitted to the relevant regulatory authority on request.
317
- 318 **3.2 RESPONSIBILITIES OF THE RESPONSIBLE PERSON**
319
- 320 3.2.1 The Responsible Person must ensure that all persons under the
321 Responsible Person's care follow and comply with the radiation
322 protection plan formulated under clause 2.1.1.
323
- 324 3.2.2 Prior to receiving a gauge, the Responsible Person or prospective
325 Responsible Person must:
- 326 (a) obtain a licence, registration or approval from the relevant
327 regulatory authority; and
- 328 (b) supply to the relevant regulatory authority:

² Relevant certificates include source activity certificate, Special Form Certificate, transport container certificate, testing certificate etc. as appropriate.

- 329 (i) information on the proposed use, storage and transport
330 arrangements;
- 331 (ii) details of what the Responsible Person intends to do with the
332 gauge once it is no longer required; and
- 333 (iii) any other information required by the relevant regulatory
334 authority.
- 335
- 336 3.2.3 Prior to the first use of a gauge, and at intervals not exceeding
337 12 months, the Responsible Person must ensure that the gauge is
338 examined:
- 339 (a) to ensure that the gauge complies with Schedule 2 of this Code of
340 Practice;
- 341 (b) for any damage or wear;
- 342 (c) to demonstrate that the source assembly and retraction
343 mechanism operate correctly and safely;
- 344 (d) to demonstrate that the gauge performs satisfactorily when used
345 in accordance with the manufacturer's instructions;
- 346 (e) to confirm that all labels³ are still intact, appropriately fitted, and
347 legible;
- 348 (f) to demonstrate that the dose rates do not exceed those specified in
349 clause 2.2 of Schedule 2 of this Code or Practice;
- 350 (g) to ensure that the shutter or source control mechanism, where
351 fitted, operates correctly and is free of dirt or other clogging agent.
352
- 353 3.2.4 The Responsible Person must ensure that the gauge is used, stored,
354 transported, routinely maintained, serviced or repaired:
- 355 (a) in accordance with the provisions of this Code; and
- 356 (b) only by appropriately qualified, authorized and, where required by
357 the relevant regulatory authority, licensed personnel.
358
- 359 3.2.5 The Responsible Person must ensure that wipe tests of the source(s)
360 and source assembly are carried out in the manner approved and at
361 times specified by the relevant regulatory authority.
362
- 363 3.2.6 If a portable density/moisture gauge is damaged, is suspected of being
364 damaged, or the results of radiation monitoring are outside the
365 expected range⁴, the Responsible Person in relation to the gauge must
366 ensure that:
- 367 (a) the relevant regulatory authority is notified immediately;
- 368 (b) the gauge is not used until it is repaired and operating correctly
369 and safely in accordance with the provisions of this Code;

³ See Annex A of the Safety Guide for the Safe Use of Portable Density/Moisture Gauges Containing Radioactive Sources (2003)

⁴ As determined under clause 2.1(a) of the Safety Guide for the Safe Use of Portable Density/Moisture Gauges Containing Radioactive Sources (2003).

- 370 (c) where applicable, the details of any repair or corrective actions
371 taken are recorded and retained; and
- 372 (d) the results of all measurements and examination of the gauge are
373 recorded and retained.
374
- 375 3.2.7 The Responsible Person must ensure that the equipment necessary to
376 implement the radiation protection plan, formulated under clause 2.1.1,
377 is available and in good working order.
378
- 379 3.2.8 The Responsible Person must ensure that radiation doses to
380 occupationally exposed persons and members of the public:
- 381 (a) are kept as low as reasonably achievable; and
- 382 (b) do not exceed the appropriate dose limits specified in the
383 *Recommendations and Standard* (see Schedule 4 of this Code).
384
- 385 3.2.9 The Responsible Person must ensure that all personnel who work with
386 or use a portable density/moisture gauge are properly instructed, and
387 reinstructed at appropriate intervals, in:
- 388 (a) radiation hazards arising from their work;
- 389 (b) precautions necessary to limit radiation exposure of themselves
390 and of other persons; and
- 391 (c) methods to avoid radiation incidents or accidents.
392
- 393 3.2.10 The Responsible Person must ensure that all radiation warning signs
394 and labels⁵ are properly located, fixed and maintained in a clean and
395 legible condition.
396
- 397 3.2.11 The Responsible Person must ensure that a Radiation Safety Officer is
398 appointed who:
- 399 (a) has sufficient professional or technical training to perform the
400 Radiation Safety Officer duties laid down in the Safety Guide for
401 the Safe Use of Portable Density/Moisture Gauges Containing
402 Radioactive Sources (2003);
- 403 (b) undertakes the measurements, investigations and assessments,
404 makes the reports, keeps the records and performs any other duty
405 required of the Radiation Safety Officer as detailed in the Safety
406 Guide and the Radiation Protection Plan;
- 407 (c) has the necessary authorisation, equipment, procedures and
408 employee cooperation so that the Radiation Safety Officer can
409 undertake the measurements, investigations and assessments,
410 make the reports and keep the records required in this Code or the
411 Safety Guide; and
- 412 (d) ensures that the Responsible Person is kept informed of the
413 radiation safety status of the practice.

⁵ As specified in Annex A of the Safety Guide for the Safe Use of Portable Density/Moisture Gauges Containing Radioactive Sources (2003).

414
415 3.2.12 In order for the Radiation Safety Officer to accomplish his or her
416 prescribed duties, the Responsible Person must not prevent the
417 Radiation Safety Officer using:

418 (a) outside experts; and

419 (b) equipment not in the possession of the Responsible Person.

420

421

422 **3.3 RESPONSIBILITIES OF THE SERVICE PROVIDER**

423

424 3.3.1 The service provider in relation to a portable density/moisture gauge
425 must ensure that all persons under the service provider's care follow
426 and comply with the radiation protection plan formulated under clause
427 2.1.1.

428

429 3.3.2 A person must not provide a service in relation to a portable
430 density/moisture gauge that contains one or more radioactive sources
431 unless that person is licensed in accordance with the requirements of
432 the relevant regulatory authority.

433

434 3.3.3 The service provider in relation to a portable density/moisture gauge
435 must ensure that a Radiation Safety Officer is appointed who:

436 (a) has sufficient professional or technical training to perform the
437 Radiation Safety Officer duties laid down in the Safety Guide for
438 the Safe Use of Portable Density/Moisture Gauges Containing
439 Radioactive Sources (2003);

440 (b) undertakes the measurements, investigations and assessments,
441 makes the reports, keeps the records and performs any other duty
442 required of the Radiation Safety Officer laid down in the Safety
443 Guide;

444 (c) has the necessary authorisation, equipment, procedures and
445 employee cooperation so that the Radiation Safety Officer can
446 undertake the measurements, investigations and assessments,
447 make the reports and keep the records required in this Code or the
448 Safety Guide; and

449 (d) ensures that the service provider is kept informed of the radiation
450 safety status of the practice.

451

452 3.3.4 In order for the Radiation Safety Officer to accomplish his or her
453 prescribed duties, the service provider in relation to a portable
454 density/moisture gauge must not prevent the Radiation Safety Officer
455 using:

456 (a) outside experts; and

457 (b) equipment not in the possession of the service provider.

458

459 3.3.5 Following the provision of a service, the service provider must ensure
460 that a report on the radiation safety status of the gauge is submitted to:

- 461 (a) the Responsible Person; and
462 (b) if required, the relevant regulatory authority.
463
- 464 3.3.6 Upon receiving a gauge for service, the service provider in relation to a
465 portable density/moisture gauge must ensure that the gauge is
466 examined for any damage or wear that may compromise radiation
467 safety.
468
- 469 3.3.7 The service provider in relation to a portable density/moisture gauge
470 must ensure that, while under the care or responsibility of the service
471 provider, the gauge is used, stored, transported or repaired:
472 (a) in accordance with the provisions of this Code of Practice; and
473 (b) only by appropriately qualified, authorized and, where required by
474 the relevant regulatory authority, licensed personnel.
475
- 476 3.3.8 Where a wipe test of the source(s) and source assembly is carried out by
477 the service provider in relation to a portable density/moisture gauge,
478 the test must be carried out in the manner approved by the relevant
479 regulatory authority.
480
- 481 3.3.9 The service provider in relation to a portable density/moisture gauge
482 must ensure that the equipment necessary to implement the radiation
483 protection plan, formulated under clause 2.1.1, is available and in good
484 working order.
485
- 486 3.3.10 The service provider in relation to a portable density/moisture gauge
487 must ensure that radiation doses to occupationally exposed persons
488 and members of the public:
489 (a) are kept as low as reasonably achievable; and
490 (b) do not exceed the appropriate dose limits specified in the
491 *Recommendations* and *Standard* (see Schedule 4 of this Code).
492
- 493 3.3.11 The service provider in relation to a portable density/moisture gauge
494 must ensure that while the gauge is under the care or responsibility of
495 the service provider, all personnel who work with, service or use the
496 gauge are properly instructed, and reinstructed at appropriate
497 intervals, in:
498 (a) radiation hazards arising from their work;
499 (b) precautions necessary to limit exposures of themselves and of
500 other persons; and
501 (c) methods to avoid radiation incidents or accidents.
502
503

504 **3.4 RESPONSIBILITIES OF THE EMPLOYEE**

505

506 3.4.1 An employee must not service, repair or adjust a portable
507 density/moisture gauge unless that employee is the holder of a licence
508 for that purpose from the relevant regulatory authority.

509

510 3.4.2 An employee must:

511 (a) where required by the relevant regulatory authority, obtain and
512 maintain a licence to use portable density/moisture gauges;

513 (b) obey all:

514 (i) notices displayed in places they occupy; and

515 (ii) instructions issued to them by the Responsible Person or the
516 Radiation Safety Officer for their safety and the safety of
517 others;

518 (c) refrain from careless or reckless practice, or action likely to result
519 in an unexpected radiation hazard to themselves or others;

520 (d) use, in a manner required by the relevant regulatory authority,
521 devices or equipment provided to them to assess their personal
522 radiation exposure;

523 (e) not interfere with, remove, alter, damage or render ineffective,
524 any portable density/moisture gauge or radiation protective
525 equipment provided to protect the employee or other persons,
526 except for authorized purposes of inspection, maintenance, repair,
527 modification or replacement;

528 (f) not interfere with any method or working procedure adopted to
529 reduce radiation exposure; and

530 (g) report to the Radiation Safety Officer any difficulties with working
531 procedures or defects in equipment that may have caused or are
532 likely to cause an unexpected radiation hazard.

533 **4. Radiation Monitoring and Radiation Levels**

534

535 **4.1 PERSONAL MONITORING DEVICES**

536

537 4.1.1 The Responsible Person or service provider must ensure that
538 thermoluminescent dosimeters (TLDs) or film badges⁶ available from
539 personal monitoring services approved by the relevant regulatory
540 authority, or other monitoring devices, are used to determine radiation
541 doses received by each person who:

542 (a) operates a portable density/moisture gauge;

543 (b) performs routine maintenance on a portable density/moisture
544 gauge; or

545 (c) undertakes service or repair of a portable density/moisture gauge.

546

547 4.1.2 The Responsible Person or service provider must seek advice from the
548 relevant regulatory authority if personal monitoring devices other than
549 TLDs or film badges are required.

550

551 4.1.3 A person who is involved with the service or repair of a portable
552 density/moisture gauge must wear a personal monitoring device or
553 other monitoring device approved by the relevant regulatory authority
554 at all times while that person may be exposed to radiation from the
555 gauge.

556

557 4.1.4 The Responsible Person, supplier or service provider must ensure that
558 the personal monitoring devices provided to each person are capable of
559 measuring the type of radiation emitted by the portable
560 density/moisture gauge being used.

561

562

563 **4.2 SURVEY METERS**

564

565 4.2.1 The Responsible Person, supplier or service provider in relation to a
566 portable density/moisture gauge must ensure that a suitable radiation
567 survey meter that meets the requirements of Schedule 3 of this Code is
568 readily available or accessible⁷ to monitor the gamma radiation levels.

569

570

⁶ **Note to 4.1.1:** These devices will be referred to collectively as personal monitoring devices.

⁷ '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. 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 of Practice.

- 571 **4.3 MANAGEMENT OF AN INCIDENT OR ACCIDENT**
572
- 573 4.3.1 In formulating the Radiation Protection Plan, the Responsible Person,
574 supplier or service provider must develop contingency arrangements
575 detailing the action to be taken following all reasonably foreseeable
576 incidents and accidents.
577
- 578 4.3.2 Immediately following an incident or accident, the Responsible Person
579 must ensure that the relevant regulatory authority is informed:
580 (a) that the incident or accident has occurred;
581 (b) of the steps that have been taken to rectify the situation; and
582 (c) of details of any radiation doses known, or suspected to have been
583 received by any person.
584
- 585 4.3.3 Where a personal monitoring device is known to have or suspected of
586 having received a radiation dose in excess of 1 mSv as a result of an
587 incident or accident, the Responsible Person, supplier or service
588 provider must submit the personal monitoring device of each person
589 concerned for urgent assessment.
590
- 591 4.3.4 In the event of an incident or accident, the Responsible Person,
592 supplier or service provider must:
593 (a) investigate the incident or accident;
594 (b) submit a complete, written report of the incident or accident,
595 including the preventative action to avoid a recurrence, to the
596 relevant regulatory authority within 7 days or in the time specified
597 by the relevant regulatory authority.

598 **5. Storage and Transport**

599

600 **5.1 STORAGE OF GAUGES**

601

602 5.1.1 Each portable density/moisture gauge must be safely and securely
603 stored when not in use subject to the following requirements:

604 (a) when in storage, the source(s) assembly must be:

605 (i) fully retracted; and

606 (ii) key locked into the shielded position;

607 (b) the gauge must not be stored with explosives, or combustible,
608 corrosive or oxidising chemicals;

609 (c) a permanent record of the fact that the gauge is stored, or has
610 been issued, must be kept by the Responsible Person, supplier or
611 service provider.

612

613 5.1.2 A store for portable density/moisture gauges must be:

614 (a) constructed of durable materials capable of physically securing the
615 gauges;

616 (b) designed and constructed so that the radiation levels outside the
617 store:

618 (i) do not result in an ambient dose equivalent rate or
619 directional dose equivalent rate, as appropriate, that exceed
620 $10 \mu\text{Sv h}^{-1}$ unless otherwise authorised by the relevant
621 regulatory authority;

622 (ii) are as low as reasonably achievable in occupied areas; and

623 (iii) are such that no member of the public can receive a dose
624 exceeding 1 mSv per year;

625 (c) under the control of the Responsible Person, supplier or service
626 provider;

627 (d) kept locked; and

628 (e) when radioactive sources are in the store, labelled with a
629 conspicuous notice⁸, the letters and symbol of which must be
630 black on yellow background, bearing:

631 (i) the radiation hazard warning symbol; and

632 (ii) the warning 'Store for Radioactive Material' or similar.

633 (f) approved by the relevant regulatory authority, where the authority
634 so requires.

635

636

⁸ An example of a suitable notice is given in 1.3 of Annex A of the Safety Guide.

637 **5.2 TRANSPORT OF GAUGES**

638

639 5.2.1 A person must not transport a portable density/moisture gauge unless
640 that person does so in accordance with the Transport Code.

641

642 5.2.2 A portable density/moisture gauge must only be transported with the
643 source assembly:

644 (a) fully retracted; and

645 (b) key locked in the shielded position.

646

647 5.2.3 Where a portable density/moisture gauge is transported in its transport
648 case, the transport case must be locked during transport.

649

650 5.2.4 A portable density/moisture gauge must not be transported in the
651 passenger compartment of the transport vehicle.

652

653 5.2.5 When a vehicle is used to regularly transport a gauge, the gauge, in its
654 case, must be fixed in the location that provides the maximum distance
655 achievable from the driver's position while minimizing shock and
656 vibration caused by the road surface.

657

658 5.2.6 The transport arrangements must be such that the security of the gauge
659 is ensured at all times.

660

661 5.2.7 The transport vehicle and the transport case must be fitted with all
662 relevant warning signs and labels required by the Transport Code.

663

664 5.2.8 In the event of an accident or other emergency, the person in charge of
665 the vehicle, or another responsible person, must notify the Responsible
666 Person or Radiation Safety Officer and the relevant regulatory
667 authority.

668

669 5.2.9 Radiation placards, as required by the Transport Code, must be
670 displayed on a vehicle transporting a portable density/moisture gauge
671 even where there are other compatible dangerous goods present.

672

673 5.2.10 'Mixed class' placards must not be used in place of the standard
674 radiation placard.

675 **6. Miscellaneous Requirements**

676
677 **6.1 REPAIRS AND MAINTENANCE**

678
679 6.1.1 A person must not carry out routine maintenance⁹ on a portable
680 density/moisture gauge containing radioactive source(s) unless that
681 person:

682 (a) is authorized to do so by the Responsible Person in relation to the
683 gauge;

684 (b) is appropriately trained in the type of maintenance being carried
685 out;

686 (c) carries out such work in accordance with the Radiation Protection
687 Plan; and

688 (d) conducts a radiation survey after any routine maintenance to
689 confirm that the dose rates do not exceed the expected range.

690
691 6.1.2 A person must not carry out repairs or maintenance on a portable
692 density/moisture gauge containing radioactive sources unless that
693 person:

694 (a) is licensed with the relevant regulatory authority to perform those
695 repairs or maintenance;

696 (b) is appropriately trained in the type of repairs or maintenance
697 being carried out;

698 (c) carries out that repair or maintenance in a workshop equipped to
699 permit safe repair; and

700 (d) conducts a radiation survey after any repairs or maintenance to
701 confirm that the dose rates do not exceed the expected range.

702
703 6.1.3 A person must not attempt any repair or alteration to the encapsulation
704 of the radioactive source unless that person is authorized to do so by
705 the relevant regulatory authority.

706
707 6.1.4 A person undertaking repairs or maintenance work must keep records
708 in accordance with any instructions that the relevant regulatory
709 authority may issue.

710
711
712 **6.2 TRANSFER OF OWNERSHIP**

713
714 6.2.1 The Responsible Person or the supplier must not transfer the
715 ownership of any portable density/moisture gauge unless this is done
716 with the approval of the relevant regulatory authority.

717
718
⁹ Routine maintenance is work intended by the manufacturer of the gauge to be performed by the Responsible Person.

719 **6.3 PROHIBITION OF DISPOSAL**

720

721 6.3.1 The Responsible Person must not dispose of a portable
722 density/moisture gauge containing a radioactive source(s) without the
723 approval of the relevant regulatory authority.

724

725

726 **6.4 ACCOUNTABILITY AND RECORDS**

727 6.4.1 *Accountability:* The Responsible Person must be able to account for all
728 radioactive sources within his or her control at all times.

729 6.4.2 *Records of radioactive sources:* The Responsible Person must
730 maintain records for each radioactive source within his or her control
731 that show:

732 (a) the whereabouts and identification number(s) of each radioactive
733 source;

734 (b) the type of radioactive source; and

735 (c) the activity and date of measurement of the activity of the
736 radioactive source.

737 6.4.3 *Annual audit:* The Responsible Person must carry out an annual audit
738 of the radioactive sources and their locations.

739 6.4.4 *Failure to account for a source:* The Responsible Person must
740 immediately notify the relevant regulatory authority if a radioactive
741 source cannot be accounted for.

742

743

744 **Schedule 1**

745

746 **Source Requirements**

747

748 **1.1 GENERAL RADIOACTIVE SOURCE REQUIREMENTS**

749

750 1.1.1 Neutron sources to be used in portable density/moisture gauges must only be
751 americium-241/beryllium or californium-252 unless an alternate radioactive
752 substance is approved by the relevant regulatory authority.

753

754 1.1.2 Radioactive substances used in portable density/moisture gauges must have
755 physical and chemical properties to minimize:

756 (a) corrosion and the build up of internal pressure; and

757 (b) dispersal or dissolution if the source encapsulation is breached.

758

759

760 **1.2 ENCAPSULATION AND CERTIFICATION OF RADIOACTIVE SOURCES**

761

762 1.2.1 Each radioactive source used in portable density/moisture gauges must be
763 'special form radioactive material' as specified in the Transport Code.

764

765 1.2.2 The design, construction and markings of each source used in portable
766 density/moisture gauges must satisfy the applicable requirements of:

767 (a) ISO (International Standard) 2919-1999(E)¹⁰; or

768 (b) any other standard or specification that is considered appropriate by the
769 relevant regulatory authority.

¹⁰ **Note to 1.2.2(a):** A radioactive source that complies with the 'special form' design and test requirements of the IAEA (International Atomic Energy Agency) would satisfy the ISO test requirements for gauges.

770 **Schedule 2**

771

772 **Gauge Requirements**

773

774 **2.1 GENERAL DESIGN REQUIREMENTS OF THE GAUGE**

775

776 2.1.1 The gauge incorporating the source(s), source assembly, source housing and
777 associated electronics, power supply and displays, must be of an integral design.

778

779 2.1.2 The source assembly, including the source(s), must not be capable of being
780 physically separated from the shielded housing under normal operational,
781 transport or storage conditions.

782

783 2.1.3 The source(s) must be fixed in the source assembly in such a manner to prevent
784 loss, dislodgment or removal of any of the sources.

785

786 2.1.4 The gauge must be designed to prevent wear, corrosion, dust, moisture,
787 vibration, heat, or any other external factor, from adversely affecting the
788 integrity of the source encapsulation, source assembly, or source shields, or
789 interfering with the ease of operation of the gauge.

790

791 2.1.5 The source assembly and retraction mechanism must be designed to prevent
792 jamming or sticking.

793

794 2.1.6 The source assembly must be capable of being key locked in the shielded
795 position.

796

797 2.1.7 The source assembly must be capable of being positively located in the:

798

(a) correct operating position(s); and

799

(b) shielded position.

800

801 2.1.8 A mechanical indicator must clearly and unambiguously indicate the source
802 position, by a label or marking, or by the position of the source assembly.

803

804 2.1.9 All components of the gauge, including the source(s), source assembly and
805 shielding, must be constructed of physically and chemically compatible
806 materials that perform satisfactorily under irradiation conditions.

807

808 2.1.10 The gauge must be labelled on its exterior surface with a durable label¹¹
809 incorporating the:

810

(a) radiation hazard warning symbol;

811

(b) name(s) of the radioactive substance(s);

812

(c) activities of the radioactive substance(s) and the date(s) of measurement;

¹¹ An example of a suitable notice is given in 1.4 of Annex A of the Safety Guide.

- 813 (d) the maximum dose rate at the gauge surface when the source(s) is/are in
814 the shielded position, and the date that this measurement was made;
- 815 (e) the name and address of the manufacturer of the gauge;
- 816 (f) the serial numbers of the source(s) and the gauge; and
- 817 (g) any other information required by the relevant regulatory authority.

818

819 2.1.11 The gauge must be durably labelled, marked or engraved in a conspicuous
820 location on the exterior surface of both the gauge and the transport case with:

- 821 (a) the Responsible Person's name or organization; and
- 822 (b) the Responsible Person's full contact telephone number.

823
824

825 **2.2 SHIELDING REQUIREMENTS**

826

827 2.2.1 When the source(s) is/are in the shielded position, the radiation levels must not
828 result in an ambient dose equivalent rate or directional dose equivalent rate, as
829 appropriate, exceeding:

- 830 (a) 250 $\mu\text{Sv h}^{-1}$ at any point 0.05 m from the gauge surface; and
- 831 (b) 10 $\mu\text{Sv h}^{-1}$ at any point 1 m from the gauge surface.

832

833 2.2.2 The shielding must be designed and constructed to withstand, without loss of
834 shielding integrity, all effects of vibration, resonance or acceleration arising
835 during normal use, storage or transport.

836

837 2.2.3 The shielding must be designed and constructed to withstand, without loss of
838 shielding integrity, temperatures and pressures arising during normal use,
839 storage and transport.

840

841 2.2.4 The shielding must be designed and constructed to standards which, from time
842 to time, may be set by the relevant regulatory authority.

843 **Schedule 3**

844

845 **Survey Meters**

846

847 **3.1 GENERAL REQUIREMENTS OF THE SURVEY METER**

848

849 3.1.1 The radiation survey meter required by clause 4.2.1 must:

850 (a) have sufficient measurement range to measure radiation dose rates at least
851 throughout the ranges of $1 \mu\text{Gy h}^{-1}$, or its equivalent, to $500 \mu\text{Gy h}^{-1}$, or its
852 equivalent for the radiations emitted from the radioactive sources under
853 the control of the Responsible Person;

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

856 (c) indicate the measured quantity with a measurement uncertainty not
857 greater than ± 20 per cent inclusive of uncertainty due to response
858 variation with energy over the range of energies of the radiation to be
859 measured.
860

861

862 **3.2 CALIBRATION OF THE SURVEY METER**

863

864 3.2.1 Radiation survey meters must have an operational and calibration check:

865 (a) prior to initial use;

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

867 (c) following damage or repairs.
868

869 3.2.2 The calibration of a radiation survey meter must be, in the case of
870 electromagnetic radiation, traceable to the Australian National Standard of air
871 kerma.

872

873 3.2.3 The calibration of a radiation survey meter must be, in the case of neutron
874 radiation, traceable to the Australian National Standard for neutron radiation.
875

876 **Schedule 4**

877
878 **ARPANSA's Recommendations for limiting exposure to**
879 **ionizing radiation (2002) – Dose Limits**
880

881

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

- 882
- 883 1. The limits shall apply to the sum of the relevant doses from external exposure in the
- 884 specified period and the 50-year committed dose (to age 70 years for children) from
- 885 intakes in the same period.
- 886 2. With the further provision that the effective dose shall not exceed 50 mSv in any single
- 887 year. In addition, when a pregnancy is declared by a female employee, the embryo or
- 888 fetus should be afforded the same level of protection as required for members of the
- 889 public.
- 890 3. When, in exceptional circumstances, a temporary change in the dose limitation
- 891 requirements is approved by the appropriate authority, one only of the following
- 892 conditions shall apply: (a) the effective dose limit shall not exceed 50 mSv per year for
- 893 the period, which shall not exceed 5 years, for which the temporary change is approved,
- 894 or (b) the period for which the 20 mSv per year average applies shall not exceed
- 895 10 consecutive years and the effective dose shall not exceed 50 mSv in any single year.
- 896 4. In special circumstances, a higher value of effective dose could be allowed in a single
- 897 year, provided that the average over 5 years does not exceed 1 mSv per year.
- 898 5. The equivalent dose limit for the skin applies to the dose averaged over any 1 cm² area of
- 899 skin, regardless of the total area exposed.

900

901

902

903

904

905 NOTE: The above dose limits table is directly extracted from ARPANSA's *Recommendations*

906 *for limiting exposure to ionizing radiation (2002)*, however the Radiation Health Committee

907 now advises that the exceptional circumstances clause in note 3 of the table is not

908 recommended for use in Australia.

909

910 **References**

- 911
912 Australian Radiation Protection and Nuclear Safety Agency 2001, *Code of Practice for the Safe*
913 *Transport of Radioactive Material 2001*, Radiation Protection Series No. 2, ARPANSA,
914 Yallambie.
- 915
916 Australian Radiation Protection and Nuclear Safety Agency 2002, *Recommendations for*
917 *Limiting Exposure to Ionizing Radiation (1995)*, and *National Occupational Health and*
918 *Safety Commission National Standard for Limiting Occupational Exposure to Ionizing*
919 *Radiation*, Radiation Protection Series No. 1, republished 2002, ARPANSA, Yallambie.
- 920
921 International Atomic Energy Agency 2000, *Regulations for the Safe Transport of Radioactive*
922 *Material 1996 Edition (Revised)*, Safety Standards Series No. TS-R-1, IAEA, Vienna.
- 923
924 International Commission on Radiological Protection 1990, *1990 Recommendations of the*
925 *International Commission on Radiological Protection*, Oxford, Pergamon Press, ICRP
926 Publication 60, Annals of the ICRP Vol. 21 No. 1-3.
- 927
928 ICRU 1993, *Quantities and units in radiation protection dosimetry*, ICRU Report 51,
929 International Commission on Radiation Units and Measurements, Bethesda, Maryland.
- 930

Glossary

931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980

accident

an unintended event which causes, or has the potential to cause, employees or members of the public to be exposed to radiation from which the individual doses or collective doses received do not lie within the range of variation which is acceptable for normal operation. An accident may result from human error, equipment failure or other mishap; it may require emergency action to save life or to safeguard health, property or the environment; it requires investigation of its causes and consequences and, possibly, corrective action within the program for control of radiation; and it may require remedial action to mitigate its consequences.

activity

the measure of quantity of radioactive materials, except when used in the term 'human activity' Activity, A , is a measure of the amount of a radioactive material given by:

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

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

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

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

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

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

contamination

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

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

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

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

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

981 **durably labelled, marked or engraved**

982
983 so marked that it is likely to retain this marking in a legible condition for the whole period of its
984 use, including during any foreseeable incident.

985
986
987 **effective dose**

988
989 the quantity E , defined as a summation of the tissue equivalent doses, each multiplied by the
990 appropriate tissue weighting factor:

991
$$E = \sum_T w_T \cdot H_T$$

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

994
995 From the definition of equivalent dose, it follows that:

996
$$E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

997 where w_R is the radiation weighting factor for radiation R and
998 $D_{T,R}$ is the average absorbed dose in the organ or tissue T.

999
1000 The unit of effective dose is J kg⁻¹, termed the sievert (Sv).

1001
1002
1003 **equivalent dose**

1004
1005 a measure of dose in organs and tissues which takes into account the type of radiation involved.

1006
1007 Equivalent dose, H , is a weighted dose in an organ or tissue, with the radiation weighting
1008 factor(s) determined by the type and energy of the radiation to which the organ or tissue is
1009 exposed. The equivalent dose H_T in organ or tissue T is given by the expression:

1010
$$H_T = \sum_T w_R \cdot D_{T,R}$$

1011 where $D_{T,R}$ is the absorbed dose averaged over the organ or tissue T due to radiation R and
1012 w_R is the radiation weighting factor for that radiation.

1013
1014 The unit of equivalent dose is the same as for absorbed dose, J kg⁻¹, with the special name
1015 sievert (Sv).

1016
1017
1018 **gamma radiation**

1019
1020 electromagnetic radiation emitted spontaneously from the nucleus of an atom in the process of
1021 a nuclear transition.

1022
1023
1024 **half-life**

1025
1026 in relation to radioactive decay, the time required for the quantity of a radionuclide to decrease
1027 to one half of its initial value.

1028

1029 **ICRP**

1030
1031 the International Commission on Radiological Protection. It is an independent organisation
1032 that provides general guidance on radiation protection. The recommendations of the ICRP are
1033 not legally binding, but are generally followed by countries framing national regulatory
1034 requirements.

1035
1036
1037 **ICRU**

1038
1039 the International Commission on Radiation Units and Measurement.

1040
1041
1042 **incident**

1043
1044 an event which causes, or has the potential to cause, abnormal exposure of employees or of
1045 members of the public and which requires investigation of its causes and consequences and
1046 may require corrective action within the program for control of radiation, but which is not of
1047 such scale as to be classified as an accident.

1048
1049
1050 **International Regulations, the**

1051
1052 means the International Atomic Energy Agency *Regulations for the Safe Transport of*
1053 *Radioactive Material 1996 Edition (Revised) (No. TS-R-1 (ST-1, Revised))* as reproduced in
1054 Schedule 1 of the Transport Code.

1055
1056
1057 **kerma, K**

1058
1059 the quotient of dE_{tr} by dm , where dE_{tr} is the sum of the initial kinetic energies of all the charged
1060 particles liberated by uncharged particles in a mass dm of material, thus

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

1061
1062 Unit: $J\ kg^{-1}$. The special name for the unit of kerma is gray (Gy).

1063
1064
1065 **neutron**

1066
1067 an elementary particle of mass 1.675×10^{-27} kg having some properties similar to the proton
1068 but carrying no charge; neutrons are constituents of all nuclei except for the stable isotope of
1069 hydrogen.

1070
1071
1072 **NHMRC**

1073
1074 the National Health and Medical Research Council. Its principal function is to advise the
1075 Australian community on matters relating to the achievement and maintenance of high
1076 standards of individual and public health through appropriate legislation, administration and
1077 practices, and to encourage health and medical research to achieve those standards.

1078 **radioactive source**

1079
1080 any quantity of radioactive material which is intended for use as a source of ionizing radiation.

1081
1082
1083 **radioactive substance**

1084
1085 material that undergoes spontaneous transformation of its nucleus with the emission of
1086 ionizing radiation and which, for the purposes of this Code and Safety Guide, exceeds a
1087 prescribed concentration or activity as determined by the relevant regulatory authority.

1088
1089
1090 **radiotoxicity**

1091
1092 the potential of radioactive material when introduced into the body to cause damage to living
1093 tissue by absorption of energy from the radiation it emits.

1094
1095
1096 **relevant regulatory authority**

1097
1098 the radiation protection authority or authorities designated, or otherwise recognized, for
1099 regulatory purposes in connection with protection and safety relating to the use of a portable
1100 density/moisture gauges containing radioactive sources. A list of radiation protection
1101 authorities in Australia is included as Annex 1 of the Code of Practice.

1102
1103
1104 **Responsible Person**

1105
1106 in relation to any radioactive source, radiation apparatus, prescribed radiation facility, or
1107 premises on which unsealed radioactive sources are stored or used, means the person:

- 1108 (a) having overall management responsibility including responsibility for the
1109 security and maintenance of the source, apparatus, or facility; and
- 1110 (b) having overall control over who may use the source or apparatus, or facility; and
- 1111 (c) in whose name the source, apparatus, or facility, would be registered if this is
1112 required.

1113
1114
1115 **source assembly**

1116
1117 the component into which the radioactive source(s) are permanently fixed. The source
1118 assembly may be movable or may itself be permanently fixed.

1119
1120
1121 **source shielding**

1122
1123 the component of the equipment, transport or storage container used to absorb or limit the
1124 external radiation when the source is in the shielded position or container. The shielding
1125 material may be lead, depleted uranium, or steel for gamma radiation shielding, and may be
1126 special plastics, water, or wax for neutron shielding.

1127
1128

1129 **supplier**

1130
1131 any legal person to whom a registrant or licensee delegates duties, totally or partially, in
1132 relation to the design, manufacture, production or construction of a source. (An importer of a
1133 source is considered a supplier of the source.)

1134
1135
1136 **Transport Code, the**

1137
1138 the Code of Practice for the Safe Transport of Radioactive Material 2001 published by the Chief
1139 Executive Officer of ARPANSA in September 2001.

1140

1141 **Annex 1**

1142

1143 **REGULATORY AUTHORITIES**

1144

1145 Where advice or assistance is required from the relevant regulatory authority, it may be
1146 obtained from the following officers:

COMMONWEALTH, STATE / TERRITORY	CONTACT
Commonwealth	Director, Regulatory Branch ARPANSA PO Box 655 Miranda NSW 1490 Email: arpansa@health.gov.au Tel: (02) 9545 8333 Fax: (02) 9545 8348
Australian Capital Territory	Director, Radiation Safety Section ACT Health GPO Box 825 Canberra ACT 2601 Email: radiation.safety@act.gov.au Tel: (02) 6207 6946 Fax: (02) 6207 6966
New South Wales	Director, Radiation Control Section Environment Protection Authority 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 Health Radiation Health Section Department of Health and Community Services GPO Box 40596 Casuarina NT 0811 Email: envirohealth@nt.gov.au Tel: (08) 8922 7489 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.branch@state.sa.gov.au Tel: (08) 8130 0700 Fax: (08) 8130 0777
Tasmania	Senior Health Physicist Health Physics Branch Department of Health & 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

1147 Please note: This table was correct at the time of printing but is subject to change from time to
1148 time. For the most up-to-date list, the reader is advised to consult the ARPANSA web site. For
1149 after hours emergencies only, the police will provide the appropriate emergency contact
1150 number.



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173

SAFETY GUIDE

**Portable Density/Moisture Gauges
Containing Radioactive Sources
(2003)**

Radiation Protection Series Publication No. ??

Public Comment Version: November 2003

This publication was approved by the Radiation Health Committee on dd mmmm yyyy, and the Radiation Health & Safety Advisory Council, at its meeting on dd mmmm yyyy, advised the CEO to adopt the Safety Guide.

1174
1175
1176

(This page intentionally left blank)

1177	Contents	
1178		
1179	1. Introduction.....	S5
1180	1.1 CITATION.....	S5
1181	1.2 BACKGROUND	S5
1182	1.3 PURPOSE	S5
1183	1.4 SCOPE	S5
1184	2. Work Practices.....	S6
1185	2.1 WORKING RULES.....	S6
1186	2.2 EMERGENCY PROCEDURES.....	S7
1187	3. Responsibilities and Duties	S9
1188	3.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON	S9
1189	3.2 DUTIES OF THE RADIATION SAFETY OFFICER	S9
1190	4. Radiation Monitoring and Radiation Levels	S11
1191	4.1 MONITORING DEVICES TO BE AVAILABLE	S11
1192	4.2 SURVEY METERS	S11
1193	5. Storage and Transport	S12
1194	5.1 STORAGE OF GAUGES.....	S12
1195	5.2 TRANSPORT OF GAUGES.....	S12
1196	6. Miscellaneous Audit, Source and Gauge Requirements	S14
1197	6.1 RESULTS OF AUDITS	S14
1198	6.2 GENERAL RADIOACTIVE SOURCE REQUIREMENTS.....	S14
1199	6.3 GENERAL DESIGN REQUIREMENTS OF THE GAUGE.....	S14
1200	Annex A RADIATION WARNING LABELS AND NOTICES	S15
1201	Annex B HEALTH EFFECTS OF IONIZING RADIATION AND	
1202	STANDARDS FOR CONTROL OF EXPOSURE	S17
1203	Annex C ARPANSA RADIATION PROTECTION SERIES	
1204	PUBLICATIONS	S20
1205		
1206		
1207		

1208
1209

(This page intentionally left blank)

1210 **1. Introduction**

1211

1212 **1.1 CITATION**

1213

1214 This Safety Guide may be cited as the *Safety Guide for Portable*
1215 *Density/Moisture Gauges Containing Radioactive Sources (2003)*.

1216

1217 **1.2 BACKGROUND**

1218

1219 The information contained in this Safety Guide is used to provide practice-
1220 specific guidance on achieving the requirements set out in the accompanying
1221 Code of Practice for Portable Density/Moisture Gauges Containing
1222 Radioactive Sources (2003) (hereafter ‘the Code’).

1223

1224 This Safety Guide provides general information on the working rules and
1225 emergency procedures that need to be considered for the mandatory
1226 requirements of the Code. General duties of the Radiation Safety Officer are
1227 also given, as is general information on personal monitoring devices, survey
1228 meters, transport and storage of gauges, auditing requirements and details of
1229 warning signs.

1230

1231 The guidance contained in the Safety Guide is not mandatory however, it is
1232 recommended that the measures included in the Safety Guide should be
1233 implemented in the interests of reducing risks.

1234

1235 **1.3 PURPOSE**

1236

1237 The purpose of this Safety Guide is:

- 1238 • to assist in the development of a Radiation Protection Plan that complies
1239 with the requirements of Section 2 of the Code; and
- 1240 • to provide other general safety guidance to assist compliance with the
1241 Code.

1242

1243 **1.4 SCOPE**

1244

1245 The scope of this Safety Guide is the same as that given in Section 1.4 of the
1246 Code.

1247 **2. Work Practices**

1248
1249 Section 2 of the Code requires that work practices be included in the Radiation
1250 Protection Plan. Work practices will include working rules that need to be
1251 followed to ensure a high standard of radiation safety and procedures that
1252 need to be followed in the event of an accident or emergency. In addition to
1253 general accident or emergency procedures, some specific scenarios should be
1254 considered, eg. fire, flood, loss of control of gauge or source(s) or unintended
1255 human exposure.

1256
1257 **2.1 WORKING RULES**

1258
1259 Working rules should be clear and easy-to-understand and should include
1260 details of:

- 1261 (a) the expected radiation levels around each portable density/moisture
1262 gauge under the control of the Responsible Person;
- 1263 (b) the correct and safe methods needed to undertake portable
1264 density/moisture measurements on the surface and at various depths
1265 using the gauge;
- 1266 (c) the methods for conducting the radiation surveys, wipe tests and any
1267 other examination required by the Code, and for reporting and
1268 recording results;
- 1269 (d) the arrangements for securing the source assembly in the shielded
1270 housing and for the security of the gauge;
- 1271 (e) arrangements for personal monitoring including:
- 1272 • the personal monitoring service provider;
 - 1273 • type of personal monitor to be worn;
 - 1274 • wearing position;
 - 1275 • requirements for storage of personal monitors when not in use; and
 - 1276 • the storage location of the control monitor,
- 1277 (f) arrangements for preventing or minimizing radiation exposure of
1278 operators and members of the public;
- 1279 (g) steps to be taken in the event of an emergency (see Section 2.2 of this
1280 Safety Guide);
- 1281 (h) any licence/registration requirements and conditions of each relevant
1282 regulatory authority in whose jurisdiction the gauge will be used;
- 1283 (i) any special instructions from or requirements of the relevant regulatory
1284 authority;
- 1285 (j) arrangements for the safe storage and transport of the gauge (see
1286 Section 5 of the Code);
- 1287 (k) arrangements for the safe calibration, repair and maintenance of the
1288 gauge;

- 1289 (l) instructions concerning the posting of radiation warning signs (Annex
1290 A Figure 1.2) when the gauge is in use; and
- 1291 (m) relevant contact addresses and telephone numbers including:
- 1292 • the Radiation Safety Officer;
- 1293 • where relevant, the service provider;
- 1294 • personal monitoring service provider; and
- 1295 • relevant regulatory authority, as well as the after hours emergency
1296 number.

1297

1298 Clear instructions on general good practices should also include the following
1299 points:

- 1300 (a) Before moving the source from its shielded housing, ensure that all
1301 people who are not required to assist with measurements are excluded
1302 from the vicinity of the gauge, eg. to a distance of 3 metres;
- 1303 (b) Keep the number of people assisting with the measurement to the
1304 absolute minimum;
- 1305 (c) While a portable density/moisture gauge is in use, the site is
1306 appropriately supervised;
- 1307 (d) Always lock the source(s) in the shielded position whenever
1308 measurements are not being made;
- 1309 (e) Never move the source(s) from the shielded housing except to make a
1310 measurement or to carry out routine maintenance (eg. cleaning of
1311 source rod);
- 1312 (f) Only move the source(s) from its housing immediately prior to making
1313 a measurement, then immediately return the source(s) to its shielding
1314 on the completion of the measurement;
- 1315 (g) Do not waste time while conducting measurements;
- 1316 (h) Do not stay close to the gauge except when necessary to conduct
1317 measurements;
- 1318 (i) Never conduct measurements unless those workers directly involved
1319 with using the gauge are correctly wearing appropriate personal
1320 monitoring devices; and
- 1321 (j) Never place the gauge where vehicles or machinery may damage it.
1322

1323 **2.2 EMERGENCY PROCEDURES**

1324

1325 Written emergency procedures for inclusion in the Radiation Protection Plan
1326 should include the following items:

- 1327 (a) instructions on the immediate actions that need to be taken to protect
1328 human life, limit injury and provide first aid where required;
- 1329 (b) instructions on the immediate procedures needed to bring the incident
1330 under control, including details on the action necessary to:

- 1331 • prevent the further spread of contamination (if this possibility
1332 arises);
- 1333 • secure an area of at least 3 metres around any unsecured source(s);
- 1334 • secure the gauge or sources and to prevent any further damage;
- 1335 • prevent unauthorized and unnecessary access to the secured area;
- 1336 • provide or augment shielding against external radiation; and
- 1337 • allay panic.
- 1338 (c) instructions for the operator involved to report the incident to the
1339 Radiation Safety Officer or the Responsible Person;
- 1340 (d) instructions for the Radiation Safety Officer to:
- 1341 • assess the nature and scope of any radiation hazard;
- 1342 • implement any further action required to bring the incident under
1343 control;
- 1344 • immediately report the incident to the Responsible Person, and to
1345 the relevant regulatory authority;
- 1346 • investigate the circumstances of the incident and undertake
1347 assessments, measurements and calculations, in order to determine
1348 the optimum corrective action plan and to estimate the doses of the
1349 operators and members of the public involved in the incident;
- 1350 • assemble the necessary resources and implement the required
1351 corrective action, taking into account instructions from the
1352 Responsible Person and the relevant regulatory authority;
- 1353 • prepare a detailed report of the incident as soon as possible after the
1354 incident and submit this report, within seven days of the incident, to
1355 the relevant regulatory authority, through the Responsible Person;
1356 and
- 1357 • advise the Responsible Person and the relevant regulatory authority
1358 on changes required to prevent the recurrence of a similar incident.
- 1359 (e) names, addresses and telephone numbers required in the event of an
1360 emergency (these should be checked and updated at least once every 12
1361 months and when changes in arrangements are made); and
- 1362 (f) any other instructions to cover possible emergencies, such as:
- 1363 • observed or suspected damage to a source or to a gauge, eg.
1364 displacement from a moving vehicle, crushing by a vehicle etc.;
- 1365 • observed or suspected malfunction of the gauge or the source
1366 assembly;
- 1367 • suspected or actual loss of the gauge or of a source;
- 1368 • failure of safety procedures or a breach of the working rules; and
- 1369 • fire, flood, explosion or other disaster or accident.

1370 **3. Responsibilities and Duties**

1371
1372 Section 2 of the Code requires that roles and responsibilities of Responsible
1373 Persons, service providers and employees involved with the use of portable
1374 density/moisture gauges be included in the Radiation Protection Plan. In
1375 addition to the mandatory responsibilities and duties specified in the Code,
1376 the following responsibilities and duties for Responsible Persons and duly
1377 appointed Radiation Safety Officers should be considered for inclusion in the
1378 Radiation Protection Plan.

1379
1380 **3.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON**

1381
1382 The Responsible Person should notify the appropriate fire authority and police
1383 of the storage locations of each portable density/moisture gauge under the
1384 Responsible Person's control. This will be of particular importance where the
1385 gauge or gauges are stored at semi-permanent or permanent locations.
1386

1387 **3.2 DUTIES OF THE RADIATION SAFETY OFFICER**

1388
1389 The Code requires that the supplier of a gauge, the Responsible Person and a
1390 service provider appoint a Radiation Safety Officer. The person appointed as
1391 the Radiation Safety Officer will typically have the following duties:

- 1392 • Obtain and maintain a knowledge of the principles and practices of
1393 radiation protection and of the potential radiation hazards associated with
1394 portable density/moisture gauges, sufficient to undertake the
1395 measurements, investigations and assessments laid down in the Code and
1396 this Safety Guide;
- 1397 • Be thoroughly familiar with the:
 - 1398 (i) requirements of the relevant radiation safety legislation;
 - 1399 (ii) provisions of the Code and this Safety Guide;
 - 1400 (iii) radiation protection plan of the organisation;
 - 1401 (iv) detailed working rules and emergency procedures adopted for use in
1402 accordance with the Code and this Safety Guide; and
 - 1403 (v) radiation survey meters, protective equipment and personal
1404 monitoring devices in use to meet the requirements of the Code and
1405 this Safety Guide;
- 1406 • Ensure that, where required by the relevant regulatory authority, personal
1407 monitoring devices and radiation survey meters are available and are in
1408 good working order;
- 1409 • Ensure that, where required by the relevant regulatory authority, operators
1410 are issued with appropriate personal monitoring devices for their exclusive
1411 use while using, storing, transporting or maintaining portable
1412 density/moisture gauges;
- 1413 • Issue and collect any personal monitoring devices that may be used;
- 1414 • Seek the advice of the relevant regulatory authority regarding any detailed
1415 conditions for use of such devices;

- 1416 • Ensure that personal monitoring devices are promptly submitted for
1417 assessment after use;
- 1418 • Ensure that individual personal monitoring devices known or reasonably
1419 suspected to have received a dose in excess of 1 mSv while being worn:
 - 1420 (a) are assessed promptly; and
 - 1421 (b) if being returned to a personal radiation monitoring service for
1422 assessment, that the service is advised of the circumstances;
- 1423 • Ensure that individual personal monitoring devices, known or reasonably
1424 suspected to have received an unusual dose while not being worn:
 - 1425 (a) are assessed promptly; and
 - 1426 (b) if being returned to a personal radiation monitoring service for
1427 assessment, that the service is advised of the circumstances;
- 1428 • Select, with the approval of the relevant regulatory authority, survey
1429 meters to meet the requirements of the Code and the Safety Guide;
- 1430 • Carry out such extra duties as are necessary to meet the requirements of
1431 the Code for storage, emergencies and for transport.

1432 **4. Radiation Monitoring and Radiation Levels**

1433
1434 In addition to the mandatory requirements for radiation monitoring specified
1435 in the Code, the following information should also be considered for inclusion
1436 in the Radiation Protection Plan.

1437
1438 **4.1 MONITORING DEVICES TO BE AVAILABLE**

1439
1440 The Responsible Person, after seeking advice from the relevant regulatory
1441 authority, should ensure that enough radiation survey meters, in working
1442 order, are available and used in accordance with the requirements specified in
1443 the Code.

1444
1445 The Responsible Person in relation to the radiation gauge should seek the
1446 advice of the relevant regulatory authority concerning the use of personal
1447 dosimeters other than film badges or thermoluminescent dosimeters.

1448
1449 **4.2 SURVEY METERS**

1450
1451 Radiation survey meters that are primarily sensitive to gamma radiation will
1452 not accurately indicate the total dose rate near a portable density/moisture
1453 gauge that also produces neutron radiation. The dose rates measured by
1454 gamma survey meters may be used to estimate the total dose rates if a suitable
1455 conversion factor has been measured and provided by the survey meter
1456 supplier. The relevant regulatory authority should be consulted in relation to
1457 such estimations.

1458
1459 The radiation survey meter should be checked against a known radiation
1460 source prior to each use to ensure that it is operating in the correct manner.
1461 Failure to do so may result in personnel being inadvertently exposed to
1462 elevated radiation levels where a monitor is malfunctioning or not calibrated.

1463
1464 The instrument's batteries should be checked regularly to ensure that they are
1465 sufficiently charged and they should be replaced or recharged if not so.

1466
1467 The gauge operator should also check the power level of the batteries in the
1468 survey meter before each use.

1469 **5. Storage and Transport**

1470

1471 In addition to the mandatory requirements for storage and transport specified
1472 in the Code, the following information should also be considered for inclusion
1473 in the Radiation Protection Plan.

1474

1475 **5.1 STORAGE OF GAUGES**

1476

1477 When in storage, the gauge should be locked in its transport case.

1478

1479 As far as practicable and taking into account the ALARA principle, portable
1480 density/moisture gauges should not be stored near regularly occupied or
1481 frequented areas. Furthermore, portable density/moisture gauges should not
1482 be stored in the same storage area as dangerous goods of the following classes:

1483

1. Explosives

1484

2.1 Flammable gas

1485

3 Flammable liquid

1486

4.1 Flammable solid

1487

4.2 Spontaneously combustible

1488

4.3 Dangerous when wet

1489

5.1 Oxidising agent

1490

5.2 Organic peroxide

1491

8 Corrosive

1492

1493 Consideration should be given to separation of these classes when designing a
1494 store from the 'ground up' or as is more often the case, when designating an
1495 existing store as a storage area for portable density/moisture gauges.

1496

1497 Also, portable density/moisture gauges should not be stored with undeveloped
1498 X-ray or photographic film or foodstuffs.

1499

1500 **5.2 TRANSPORT OF GAUGES**

1501

1502 When transported on public roads, the gauge, wherever possible, should be
1503 locked in its carry case and be fixed in location within the vehicle with the
1504 shutter mechanism facing away from the vehicle occupants or facing
1505 downwards.

1506

1507 Loading restrictions also exist for the transport of portable density/moisture
1508 gauges with other dangerous goods with the class restriction being the same as
1509 those given for storage as outlined above. The Australian Dangerous Goods
1510 Code (ADGC), as amended from time to time, specifies the criteria for the
1511 transport of mixed dangerous goods on the one conveyance. The ADGC
1512 should be checked before a portable density/moisture gauge is transported
1513 with any other dangerous goods on the one conveyance. In general though,
1514 mixing incompatible classes of dangerous goods on the one conveyance would
1515 not be permitted unless there is segregation of at least 12 metres and for some
1516 mixed classes, 24 metres.

1517

1518 Where other compatible dangerous goods are being transported on or in a
1519 vehicle, it may be necessary to have two sets of placards indicating that the
1520 vehicle is carrying a portable density/moisture gauge and another class of
1521 dangerous goods.

1522

1523 While the packaging, labelling and paperwork required for the transport of
1524 radioactive material is uniform throughout Australia, the licensing across the
1525 jurisdictions may not be. If transporting a portable density/moisture gauge
1526 across a jurisdictional boundary, it is highly recommended to ascertain the
1527 licensing requirements of each jurisdiction through or into which the portable
1528 density/moisture gauge will be transported.

1529 **6. Miscellaneous Audit, Source and Gauge**
1530 **Requirements**

1531
1532 The following information should also be considered for inclusion in the
1533 Radiation Protection Plan.

1534
1535 **6.1 RESULTS OF AUDITS**

1536
1537 The results of any audit of gauges or radioactive sources required by the Code
1538 should be sent to the relevant regulatory authority.

1539
1540 **6.2 GENERAL RADIOACTIVE SOURCE REQUIREMENTS**

1541
1542 The radioactive sources used in portable density/moisture gauges should:

- 1543 (a) only incorporate radioactive substances that have the minimum activity
1544 and half-life, consistent with the projected useful life of the gauge; and
1545 (b) emit radiation of the type and energy appropriate for the particular
1546 application.

1547
1548 Radioactive substances that are very highly radiotoxic should not be used for
1549 portable density/moisture gauges, unless:

- 1550 (a) no other suitable lower radiotoxicity substance is available; or
1551 (b) the radioactive substance is being used to produce neutrons.

1552
1553 **6.3 GENERAL DESIGN REQUIREMENTS OF THE GAUGE**

1554
1555 The radioactive sources should be either permanently mounted within the
1556 source housing of the gauge or permanently fixed in the moveable assembly.

1557
1558 The gauge should be robust, easy to use and portable.

1559

1560 **Annex A**

1561

1562 **Radiation warning labels and notices**

1563

1564 Radiation warning signs and notices, must conform to AS 1319 - 1994 *Safety signs for*
1565 *the occupational environment*, and AS 2342 - 1992 *Development, testing and*
1566 *implementation of information and safety symbols and symbolic signs*. Examples of
1567 suitable warning notices are given below.
1568

1569 **1.1 COLOURS FOR RADIATION WARNING LABELS AND NOTICES**

1570

1571 Background: yellow

1572 Marking and trefoil: black

1573 (NOTE: the lower part of label 1.4 may be unpainted metal with black lettering).
1574

1575 **1.2 EXAMPLE OF SUITABLE WARNING NOTICE FOR POSTING IN**
1576 **THE AREA ADJACENT TO PORTABLE DENSITY/MOISTURE**
1577 **GAUGE WHEN IN USE**




1578

1579 **1.3 EXAMPLE OF A SUITABLE WARNING NOTICE FOR A STORE**



1580
1581
1582

1.4 EXAMPLE OF A SUITABLE WARNING LABEL FOR ATTACHMENT TO A PORTABLE DENSITY/MOISTURE GAUGE CONTAINING A RADIOACTIVE SOURCE



RADIATION SOURCE

PORTABLE DENSITY/MOISTURE GAUGE

MANUFACTURED BY:

MODEL No.: SERIAL No.:

MAX DOSE RATE AT ONE METRE:

DATE DOSE RATE MEASURED:

RADIOACTIVE SOURCE

RADIOACTIVE MATERIAL:

ACTIVITY: DATE OF MEAS:

SUPPLIED BY:

ADDRESS:

MODEL No.: SERIAL No.:

ISO CLASS No.:

1583
1584
1585
1586

The information included on this label should reflect the gauge's use (eg. density only, moisture only or combination (version depicted above)) and its total radioactive contents (eg. caesium only, Am-241/Be only or both).

1587 **Annex B**

1588

1589 **Health Effects of Ionizing Radiation and Standards for**
1590 **Control of Exposure**

1591

1592 It is well known that high doses of ionizing radiation can cause harm, but there is
1593 continuing scientific uncertainty about effects at low doses. At levels of dose
1594 routinely encountered by members of the public and most present-day radiation
1595 workers, there is little or no epidemiological evidence of health effects. Radiation
1596 protection standards recognize that it is not possible to eliminate all radiation
1597 exposure, but they do provide for a system of control to avoid unnecessary exposure
1598 and to keep doses in the low dose range.

1599

1600 Extreme doses of radiation to the whole body (around 10 sievert* and above),
1601 received in a short period, cause so much damage to internal organs and tissues of
1602 the body that vital systems cease to function and death may result within days or
1603 weeks. Very high doses (between about 1 sievert and 10 sievert), received in a short
1604 period, kill large numbers of cells, which can impair the function of vital organs and
1605 systems. Acute health effects, such as nausea, vomiting, skin and deep tissue burns,
1606 and impairment of the body's ability to fight infection may result within hours, days
1607 or weeks. The extent of the damage increases with dose. However, 'deterministic'
1608 effects such as these are not observed at doses below certain thresholds. By limiting
1609 doses to levels below the thresholds, deterministic effects can be prevented entirely.

1610

1611 Doses below the thresholds for deterministic effects may cause cellular damage, but
1612 this does not necessarily lead to harm to the individual: the effects are probabilistic or
1613 'stochastic' in nature. It is known that doses above about 100 millisievert, received in
1614 a short period, lead to an increased risk of developing cancer later in life. There is
1615 good epidemiological evidence – especially from studies of the survivors of the atomic
1616 bombings – that, for several types of cancer, the risk increases roughly linearly with
1617 dose, and that the risk factor averaged over all ages and cancer types is about 1 in 100
1618 for every 100 millisievert of dose (i.e. 1 in 10 000 per millisievert).

1619

1620 At doses below about 100 millisievert, the evidence of harm is not clear-cut. While
1621 some studies indicate evidence of radiation-induced effects, epidemiological research
1622 has been unable to establish unequivocally that there are effects of statistical
1623 significance at doses below a few tens of millisieverts. Nevertheless, given that no
1624 threshold for stochastic effects has been demonstrated, and in order to be cautious in
1625 establishing health standards, the proportionality between risk and dose observed at
1626 higher doses is presumed to continue through all lower levels of dose to zero. This is
1627 called the linear, no-threshold (LNT) hypothesis and it is made for radiation
1628 protection purposes only.

1629

1630 There is evidence that a dose accumulated over a long period carries less risk than the
1631 same dose received over a short period. Except for accidents and medical exposures,
1632 doses are not normally received over short periods, so that it is appropriate in
1633 determining standards for the control of exposure to use a risk factor that takes this
1634 into account. While not well quantified, a reduction of the high-dose risk factor by a
1635 factor of two has been adopted internationally, so that for radiation protection
1636 purposes the risk of radiation-induced fatal cancer (the risk factor) is taken to be
1637 about 1 in 20 000 per millisievert of dose for the population as a whole.

1638

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

1639 If the LNT hypothesis is correct, any dose carries some risk. Therefore, measures for
1640 control of exposure for stochastic effects seek to avoid all reasonably avoidable risk.
1641 This is called optimizing protection. However, risk in this sense may often be
1642 assessed in terms of risk to a population, and may not ensure sufficient protection of
1643 the individual. Consequently, the optimization approach is underpinned by applying
1644 dose limits that restrict the risk to individuals to an acceptable level. The
1645 fundamental regulatory philosophy is expressed in three principles, based on the
1646 recommendations of the International Commission on Radiological Protection
1647 (ICRP), which may be summarized as follows:

1648
1649 *Justification:* human activities that cause exposure to radiation may be
1650 permitted only if they do more good than harm;

1651 *Optimization of protection:* exposure to radiation from justified activities
1652 should be kept as low as reasonably achievable, social and economic factors
1653 being taken into account; and

1654 *Limitation of individual dose:* doses must not exceed the prescribed dose
1655 limits.

1656
1657 Determining what is an acceptable risk for regulatory purposes is a complex value
1658 judgement. The ICRP reviewed a number of factors in developing its
1659 recommendations, which have in general been internationally endorsed, including by
1660 the World Health Organization, the International Labour Organisation and the
1661 International Atomic Energy Agency. Australia's Radiation Health Committee, now
1662 established under the ARPANS Act[†], has recommended that the international
1663 standards be adopted in Australia. The recommended dose limits are summarized as
1664 follows:

Limit on effective dose*

1667	For occupational	For members of
1668	exposure	the public
1669	20 mSv per year,	1 mSv in a year*
1670	averaged over 5 years*	

1671 *for details, see ARPANSA's *Recommendations for limiting exposure to ionizing radiation*
1672 (2002)

1673
1674 In most situations, the requirements for limiting individual risk ensure that doses are
1675 below deterministic thresholds, but for cases where this does not apply, the
1676 recommended limits are as follows:

Annual limit on equivalent dose*

1678	For occupational	For members of
1679	exposure	the public
1680		
1681		
1682	150 mSv	15 mSv
1683	500 mSv	50 mSv
1684	500 mSv	–

1685 *for details, see ARPANSA's *Recommendations for limiting exposure to ionizing radiation*
1686 (2002)

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

1688 In the case of occupational exposure during pregnancy, the general principle is that the
1689 embryo or fetus should be afforded the same level of protection as is required for a member
1690 of the public. For medical workers, the ICRP recommends that there should be a reasonable
1691 assurance that fetal dose can be kept below 1 mGy* during the course of the pregnancy. This
1692 guidance may be generalised to cover all occupationally exposed pregnant workers by
1693 keeping the fetal dose below 1 mSv. A full explanation of radiation protection principles and
1694 of the recommended standards for Australia is given in ARPANSA/NOHSC Radiation
1695 Protection Series No. 1: *Recommendations for limiting exposure to ionizing radiation (1995)*
1696 and *National standard for limiting occupational exposure to ionizing radiation (both*
1697 *republished 2002)*.
1698
1699
1700

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

1701 **Annex C**

1702

1703 **ARPANSA Radiation Protection Series Publications**

1704

1705 ARPANSA has taken over responsibility for the administration of the former NHMRC
1706 Radiation Health Series of publications and for the codes developed under the *Environment*
1707 *Protection (Nuclear Codes) Act 1978*. The publications are being progressively reviewed and
1708 republished as part of the *Radiation Protection Series*. All publications listed below are
1709 available in electronic format, and can be downloaded free of charge by visiting ARPANSA's
1710 website at <http://www.arpansa.gov.au/pubs.htm>.

1711 Radiation Protection Series publications are available for purchase directly from ARPANSA.
1712 Further information can be obtained by telephoning ARPANSA on 1800 022 333 (freecall
1713 within Australia) or (03) 9433 2211.

1714 **RADIATION PROTECTION SERIES**

1715 RPS 1. Recommendations for Limiting Exposure to Ionizing Radiation (1995) and
1716 National Standard for Limiting Occupational Exposure to Ionizing Radiation
1717 (republished 2002)

1718 RPS 2. Code of Practice for the Safe Transport of Radioactive Material (2001)

1719 RPS 3. Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz (2002)

1720 RPS 4. Recommendations for the Discharge of Patients Undergoing Treatment with
1721 Radioactive Substances (2002)

1722 RPS # Code of Practice and Safety Guide for Portable Density/Moisture Gauges
1723 Containing Radioactive Sources (2003).

1724 Current publications from the NHMRC Radiation Health Series and the Environment
1725 Protection (Nuclear Codes) Act Series are available free of charge by contacting ARPANSA on
1726 (03) 9433 2211 or email arpansa@health.gov.au. Publications that are still current are:

1727 **RADIATION HEALTH SERIES**

1728 RHS 2. Code of practice for the design of laboratories using radioactive substances for
1729 medical purposes (1980)

1730 RHS 3. Code of practice for the safe use of ionizing radiation in veterinary radiology: Parts
1731 1 and 2 (1982)

1732 RHS 4. Code of practice for the safe use of radiation gauges (1982)

1733 RHS 8. Code of nursing practice for staff exposed to ionizing radiation (1984)

1734 RHS 9. Code of practice for protection against ionizing radiation emitted from X-ray
1735 analysis equipment (1984)

1736 RHS 10. Code of practice for safe use of ionizing radiation in veterinary radiology: part
1737 3-radiotherapy (1984)

1738 RHS 12. Administration of ionizing radiation to human subjects in medical research (1984)

1739 RHS 13. Code of practice for the disposal of radioactive wastes by the user (1985)

1740 RHS 14. Recommendations for minimising radiological hazards to patients (1985)

1741 RHS 15. Code of practice for the safe use of microwave diathermy units (1985)

1742 RHS 16. Code of practice for the safe use of short wave (radiofrequency) diathermy units
1743 (1985)

DRAFT FOR PUBLIC COMMENT

- 1744 RHS 17. Procedure for testing microwave leakage from microwave ovens (1985)
- 1745 RHS 18. Code of practice for the safe handling of corpses containing radioactive materials
1746 (1986)
- 1747 RHS 19. Code of practice for the safe use of ionizing radiation in secondary schools (1986)
- 1748 RHS 20. Code of practice for radiation protection in dentistry (1987)
- 1749 RHS 21. Revised statement on cabinet X-ray equipment for examination of letters,
1750 packages, baggage, freight and other articles for security, quality control and other
1751 purposes (1987)
- 1752 RHS 22. Statement on enclosed X-ray equipment for special applications (1987)
- 1753 RHS 23. Code of practice for the control and safe handling of radioactive sources used for
1754 therapeutic purposes (1988)
- 1755 RHS 24. Code of practice for the design and safe operation of non-medical irradiation
1756 facilities (1988)
- 1757 RHS 25. Recommendations for ionization chamber smoke detectors for commercial and
1758 industrial fire protection systems (1988)
- 1759 RHS 26. Policy on stable iodine prophylaxis following nuclear reactor accidents (1989)
- 1760 RHS 28. Code of practice for the safe use of sealed radioactive sources in bore-hole logging
1761 (1989)
- 1762 RHS 29. Occupational standard for exposure to ultraviolet radiation (1989)
- 1763 RHS 30. Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields
1764 (1989)
- 1765 RHS 31. Code of practice for the safe use of industrial radiography equipment (1989)
- 1766 RHS 32. Intervention in emergency situations involving radiation exposure (1990)
- 1767 RHS 34. Safety guidelines for magnetic resonance diagnostic facilities (1991)
- 1768 RHS 35. Code of practice for the near-surface disposal of radioactive waste in Australia
1769 (1992)
- 1770 RHS 36. Code of practice for the safe use of lasers in schools (1995)
- 1771 RHS 37. Code of practice for the safe use of lasers in the entertainment industry (1995)
- 1772 RHS 38. Recommended limits on radioactive contamination on surfaces in laboratories
1773 (1995)

1774 **ENVIRONMENT PROTECTION (NUCLEAR CODES) ACT SERIES**

- 1775 Code of Practice on the Management of Radioactive Wastes from the Mining and Milling of
1776 Radioactive Ores 1982
- 1777 Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores 1987
1778

1779 **Index**
1780

(To be inserted at a later date)

1 **Contributors to Drafting and Review**

2

3

4 **Working Group**

5

6 Mr Keith Dessent, ARPANSA (convenor)

7 Mr Sergio Costantin, Department of Human Services, Victoria

8 Mr Simon Critchley, Department of Health, Queensland

9 Mr Gary Kelk, Geotest Australia Pty Ltd., Queensland

10 Mr Mark Owtrim, Main Roads, Queensland