Australian Government
Australian Radiation Protection and Nuclear Safety Agency

CODE OF PRACTICE & SAFETY GUIDE

Portable Density/Moisture Gauges Containing Radioactive Sources

RADIATION PROTECTION SERIES No. 5

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.

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Portable Density/Moisture Gauges Containing Radioactive Sources (2004)

Radiation Protection Series Publication No. 5

May 2004

This publication was approved by the Radiation Health Committee on 18 March 2004, and the Radiation Health and Safety Advisory Council, at its meeting on 2 April 2004, advised the CEO to adopt the Code of Practice and Safety Guide.

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

Published by the Chief Executive Officer of ARPANSA in May 2004

Foreword

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

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

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

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

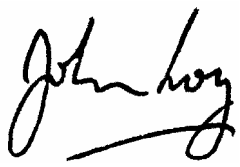
This Code of Practice and Safety Guide has been developed by a working group of the Radiation Health Committee, which has reviewed the 1984 NHMRC Code of Practice with a view to replacing it. The Code establishes requirements for adoption by Commonwealth, State and Territory jurisdictions that will provide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

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

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

The Code was released for a public comment period from 17 November 2003 to 19 December 2003 along with a Regulatory Impact Statement, to meet the requirements of the *Principles and Guidelines for National Standard-setting and Regulatory Action by Ministerial Councils and Standard-setting Bodies* published by the Council of Australian Governments in November 1997. The comments received were reviewed by the working group, and the final document was approved by the Radiation Health Committee on 18 March 2004, and the Radiation Health and Safety Advisory Council at their meeting of 2 April 2004 advised the CEO to adopt the Code.

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



John Loy
CEO of ARPANSA

18 May 2004

Contents

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

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Contents

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1. Introduction

1.1 Citation

This Code of Practice may be cited as the *Code of Practice for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*.

1.2 Background

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

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

The radiation safety legislation of the State, Territory or Commonwealth jurisdiction in which a person is working may require that person to hold an **authorisation** from the **relevant regulatory authority**. This would need to be confirmed with the relevant regulatory authority for each jurisdiction in which that person is working. Particular consideration will need to be given in the case where a person may need to cross a State/Territory/Commonwealth border or boundary.

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

1.3 Purpose

The purpose of this Code is to establish working practices, procedures and protective measures and to ensure the security of radioactive sources. This will ensure that the dose limits specified in Schedule D are not exceeded. In addition, the Code will assist in keeping radiation doses arising from a portable density/moisture gauge containing radioactive sources as low as reasonably achievable, economic and social factors taken into account (the **ALARA** principle).

1.4 Scope

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

Devices that have a separate probe containing a radioactive source and separate **source shielding**, and which are designed to measure soil density, moisture or mineralisation in bore holes greater than a depth of 10 metres, are not covered by this Code.

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

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

1.5 UNITS OF MEASUREMENT

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

2. Radiation Management Plan

2.1 Each **Responsible Person**, **supplier** or **service provider** who deals with a portable density/moisture gauge must ensure that a Radiation Management Plan is developed, documented, implemented and regularly reviewed to ensure safety in all applicable dealings with the portable density/moisture gauge, including:

(a) work practices[1];

(b) roles and responsibilities (Section 3);

(c) radiation monitoring requirements, including details of how the availability or accessibility requirements for the monitoring equipment are to be achieved (Section 4);

(d) control of an **incident** involving the gauge (Section 4.3);

(e) storage of the gauge (Section 5.1);

(f) transport of the gauge (Section 5.2);

(g) repairs and maintenance of the gauge (Section 6.1);

(h) what to do with the gauge (eg. sale, transfer, disposal) when it is no longer required (Sections 6.2 and 6.3);

(i) accountability and records (Section 6.4); and

(j) any other requirement that may have a bearing on safety.

[1] Guidelines for formulating work practices, including working rules and emergency procedures, are given in Section 2 of the Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004).

3. Responsibilities and Duties

3.1 RESPONSIBILITIES OF SUPPLIERS

3.1.1 The supplier of a portable density/moisture gauge must ensure that all persons under the supplier's care follow and comply with the Radiation Management Plan formulated under clause 2.1.

3.1.2 The supplier must ensure that the Radiation Management Plan is reviewed and updated at appropriate intervals.

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

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

(b) the person to whom the gauge is supplied is authorised in accordance with the requirements of the relevant regulatory authority.

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

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

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

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

(a) the construction details of the gauge including details of the:
  (i) source position; and
  (ii) shielding included in the gauge,

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

(c) for each radioactive source to be contained in the gauge, details of the:
  (i) type of radioactive source;
  (ii) maximum **activity** of the radioactive source;
  (iii) encapsulation details of the radioactive source; and
  (iv) special form certificate for the radioactive source (see Schedule A of this Code),

(d) the maximum radiation dose rates at distances of 0.05 m and 1 m from the gauge surface when the gauge is loaded with the maximum activity of each radioactive source for which the gauge was designed;

(e) the radiation dose rate profile around the gauge including at locations normally occupied by operators during gauge use;

(f) such other details as may be required by the relevant regulatory authority to assess compliance with the requirements of this Code.

3.1.8 Prior to the transfer of a portable density/moisture gauge, the supplier must:

(a) supply the relevant regulatory authority with the name and address of the purchaser or proposed operator;

(b) ensure that the portable density/moisture gauge is capable of correct and safe operation in accordance with the provisions of this Code; and

(c) supply to the purchaser or proposed operator all of the relevant information listed in clause 3.1.7 together with operating and maintenance instructions to permit the purchaser or proposed operator to correctly and safely operate the gauge in accordance with the provisions of this Code.

3.1.9 The supplier of a radioactive source must ensure that each radioactive source is:

(a) or has been, tested to demonstrate compliance with the requirements of Schedule A of this Code; and

(b) accompanied by all relevant certificates[2].

3.1.10 The supplier of a radioactive source must ensure that copies of all relevant certificates are:

(a) provided to the Responsible Person at the time that the device is delivered to the Responsible Person; and

(b) submitted to the relevant regulatory authority on request.

3.2 RESPONSIBILITIES OF THE RESPONSIBLE PERSON

3.2.1 The Responsible Person must ensure that all persons under the Responsible Person's care follow and comply with the Radiation Management Plan formulated under clause 2.1.

3.2.2 The Responsible Person must ensure that the Radiation Management Plan is reviewed and updated at appropriate intervals.

3.2.3 Prior to receiving a gauge, the Responsible Person or prospective Responsible Person must:

[2] Relevant certificates include source activity certificate, special form certificate, transport container certificate, testing certificate etc. as appropriate.

(a) obtain an authorisation from the relevant regulatory authority; and

(b) supply to the relevant regulatory authority:

(i) information on the proposed use, storage and transport arrangements;

(ii) details of what the Responsible Person intends to do with the gauge once it is no longer required; and

(iii) any other information required by the relevant regulatory authority.

3.2.4 Prior to the first use of a gauge, and at intervals not exceeding 12 months, the Responsible Person must ensure that the gauge is examined:

(a) to ensure that the gauge complies with Schedule B of this Code;

(b) for any damage or wear;

(c) to demonstrate that the **source assembly** and retraction mechanism operate correctly and safely;

(d) to demonstrate that the gauge performs satisfactorily when used in accordance with the manufacturer's instructions;

(e) to confirm that all labels[3] are still intact, appropriately fitted, and legible;

(f) to demonstrate that the dose rates do not exceed those specified in clause B2.1 of Schedule B of this Code; and

(g) to ensure that the shutter or source control mechanism, where fitted, operates correctly and is free of dirt or other clogging agent.

3.2.5 The Responsible Person must ensure that records are maintained of all examinations listed in clause 3.2.4 (a) to (g) of this Code.

3.2.6 The Responsible Person must ensure that the gauge is used, stored, transported, routinely maintained, serviced or repaired:

(a) in accordance with the provisions of this Code; and

(b) only by appropriately qualified and, where required by the relevant regulatory authority, authorised personnel.

3.2.7 The Responsible Person must ensure that wipe tests of the source(s) and source assembly are carried out in the manner approved and at times specified by the relevant regulatory authority.

3.2.8 If a portable density/moisture gauge is damaged, is suspected of being damaged, or the results of radiation monitoring are outside the

[3] See Annex A of the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*

expected range[4], the Responsible Person in relation to the gauge must ensure that:

(a) the relevant regulatory authority is notified immediately;

(b) the gauge is not used until it is repaired and operating correctly and safely in accordance with the provisions of this Code;

(c) where applicable, the details of any repair or corrective actions taken are recorded and retained; and

(d) the results of all measurements and examination of the gauge are recorded and retained.

3.2.9 The Responsible Person must ensure that the equipment necessary to implement the Radiation Management Plan, formulated under clause 2.1, is available and in good working order.

3.2.10 The Responsible Person must ensure that radiation doses to occupationally exposed persons and members of the public:

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

(b) do not exceed the appropriate dose limits specified Schedule D of this Code.

3.2.11 The Responsible Person must ensure that all personnel who work with or use a portable density/moisture gauge are properly instructed, and reinstructed at appropriate intervals, in:

(a) radiation hazards arising from their work;

(b) precautions necessary to limit radiation exposure of themselves and of other persons; and

(c) methods to avoid radiation incidents.

3.2.12 The Responsible Person must ensure that all radiation warning signs and labels[5] are properly located, fixed and maintained in a clean and legible condition.

3.2.13 The Responsible Person must ensure that a Radiation Safety Officer is appointed[6] who:

(a) has sufficient professional or technical training to perform the Radiation Safety Officer duties laid down in the Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004);

(b) undertakes the measurements, investigations and assessments, makes the reports, keeps the records and performs any other duty required of the Radiation Safety Officer as detailed in the Safety Guide and the Radiation Management Plan;

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4 As determined under clause 2.1(a) of the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004).*

5 As specified in Annex A of the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004).*

6 The Responsible Person and the Radiation Safety Officer may be the same person but if so, will need to comply with the obligations of both.

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

(d) ensures that the Responsible Person is kept informed of the radiation safety status of the practice.

3.2.14 In order for the Radiation Safety Officer to accomplish his or her prescribed duties, the Responsible Person must not prevent the Radiation Safety Officer using:

(a) outside experts; and

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

3.3 RESPONSIBILITIES OF THE SERVICE PROVIDER

3.3.1 The service provider in relation to a portable density/moisture gauge must ensure that all persons under the service provider's care follow and comply with the Radiation Management Plan formulated under clause 2.1.

3.3.2 The service provider must ensure that the Radiation Management Plan is reviewed and updated at appropriate intervals.

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

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

(a) has sufficient professional or technical training to perform the Radiation Safety Officer duties laid down in the Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004);

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

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

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

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

(a) outside experts; and

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

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

(a) the Responsible Person; and

(b) if required, the relevant regulatory authority.

3.3.7 Upon receiving a gauge for service, the service provider in relation to a portable density/moisture gauge must ensure that the gauge is examined for any damage or wear that may compromise radiation safety.

3.3.8 The service provider in relation to a portable density/moisture gauge must ensure that, while under the care or responsibility of the service provider, the gauge is used, stored, transported or repaired:

(a) in accordance with the provisions of this Code; and

(b) only by appropriately qualified and, where required by the relevant regulatory authority, authorised personnel.

3.3.9 Where a wipe test of the source(s) and source assembly is carried out by the service provider in relation to a portable density/moisture gauge, the test must be carried out in the manner approved by the relevant regulatory authority.

3.3.10 The service provider in relation to a portable density/moisture gauge must ensure that the equipment necessary to implement the Radiation Management Plan, formulated under clause 2.1, is available and in good working order.

3.3.11 The service provider in relation to a portable density/moisture gauge must ensure that radiation doses to occupationally exposed persons and members of the public:

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

(b) do not exceed the appropriate dose limits specified in Schedule D of this Code.

3.3.12 The service provider in relation to a portable density/moisture gauge must ensure that while the gauge is under the care or responsibility of the service provider, all personnel who work with, service or use the gauge are properly instructed, and reinstructed at appropriate intervals, in:

(a) radiation hazards arising from their work;

(b) precautions necessary to limit exposures of themselves and of other persons; and

(c) methods to avoid radiation incidents.

3.4 RESPONSIBILITIES OF THE OPERATOR OR USER

3.4.1 A person must not service, repair or adjust a portable density/moisture gauge unless that person is the holder of an authorisation for that purpose from the relevant regulatory authority.

3.4.2 A person must:

(a) where required by the relevant regulatory authority, obtain and maintain an authorisation to operate or use a portable density/moisture gauge;

(b) obey all:

(i) signs displayed in places they occupy; and

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

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

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

(e) not interfere with, remove, alter, damage or render ineffective, any portable density/moisture gauge or radiation protective equipment provided to protect the operator or user or other persons, except for authorised purposes of inspection, maintenance, repair, modification or replacement;

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

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

(h) follow all requirements of the Radiation Management Plan that are applicable to that person.

4. Radiation Monitoring and Radiation Levels

4.1 PERSONAL MONITORING DEVICES

4.1.1 The Responsible Person, supplier or service provider must provide a personal monitoring device approved by the relevant regulatory authority to determine radiation doses received by each person who:

(a) operates a portable density/moisture gauge;

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

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

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

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

4.2 SURVEY METERS

4.2.1 The Responsible Person, supplier or service provider in relation to a portable density/moisture gauge must ensure that a suitable radiation survey meter that meets the requirements of Schedule C of this Code is readily available or accessible[7] to monitor the gamma radiation levels.

4.3 MANAGEMENT OF AN INCIDENT

4.3.1 In formulating the Radiation Management Plan, the Responsible Person, supplier or service provider must develop contingency arrangements detailing the action to be taken following all reasonably foreseeable incidents.

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

(a) that the incident has occurred;

(b) of the steps that have been taken to rectify the situation; and

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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. Details of how the availability or accessibility of the survey meter are to be achieved are to be included in the Radiation Management Plan. The borrowing, hiring or sharing of a survey meter does not alleviate the Responsible Person, supplier or service provider from the survey monitoring requirements of this Code.

(c) of details of any radiation doses known, or suspected to have been received by any person.

4.3.3 Where a personal monitoring device is known to have or suspected of having received a radiation dose in excess of 1 mSv as a result of an incident, the Responsible Person, supplier or service provider must submit the personal monitoring device of each person concerned for urgent assessment.

4.3.4 In the event of an incident, the Responsible Person, supplier or service provider must:

(a) investigate the incident; and

(b) submit a complete, written report of the incident, including the preventative action to avoid a recurrence, to the relevant regulatory authority within 7 days or in the time specified by the relevant regulatory authority.

5. Storage and Transport

5.1 STORAGE OF GAUGES

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

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

(i) fully retracted; and

(ii) key locked into the shielded position;

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

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

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

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

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

(i) do not result in an ambient dose equivalent rate or directional dose equivalent rate, as appropriate, that exceeds 10 μSv h^{-1} unless otherwise authorised by the relevant regulatory authority;

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

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

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

(d) when radioactive sources are in the store, labelled with a conspicuous sign[8], the letters and symbol of which must be black on yellow background, bearing:

(i) the radiation hazard warning symbol; and

(ii) the warning 'Store for Radioactive Materials' or similar;

(e) kept locked; and

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

[8] An example of a suitable sign is given in Annex A of the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*.

5.2 TRANSPORT OF GAUGES

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

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

(a) fully retracted; and

(b) key locked in the shielded position.

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

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

5.2.5 During transport, the gauge, in its transport case, must be securely stowed in the location that provides the maximum distance achievable from the driver's position while minimising shock and vibration caused by the road surface.

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

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

5.2.8 In the event of an incident or other emergency, the person in charge of the vehicle, or another Responsible Person, must notify the Responsible Person or Radiation Safety Officer and the relevant regulatory authority.

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

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

6. Miscellaneous Requirements

6.1 REPAIRS AND MAINTENANCE

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

(a) is authorised to do so by the Responsible Person in relation to the gauge;

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

(c) carries out such work in accordance with the Radiation Management Plan; and

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

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

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

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

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

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

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

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

6.2 TRANSFER OF OWNERSHIP

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

6.3 PROHIBITION OF DISPOSAL

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

6.4 ACCOUNTABILITY AND RECORDS

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

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

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

(b) the type of radioactive source; and

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

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

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

Schedule A

Source Requirements

A1 GENERAL RADIOACTIVE SOURCE REQUIREMENTS

A1.1 **Neutron** sources to be used in portable density/moisture gauges must only be americium-241/beryllium or californium-252 unless an alternate **radioactive substance** is approved by the relevant regulatory authority.

A1.2 Radioactive substances used in portable density/moisture gauges must have physical and chemical properties to minimise:

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

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

A2 ENCAPSULATION AND CERTIFICATION OF RADIOACTIVE SOURCES

A2.1 Each radioactive source used in portable density/moisture gauges must be 'special form radioactive material' as specified in the Transport Code.

A2.2 The design, construction and markings of each source used in portable density/moisture gauges must satisfy the applicable requirements of:

(a) ISO (International Standard) 2919-1999(E)[9]; or

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

[9] **Note to A2.2(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.

Schedule B

Gauge Requirements

B1 GENERAL DESIGN REQUIREMENTS OF THE GAUGE

B1.1 The gauge incorporating the source(s), source assembly, source housing and associated electronics, power supply and displays, must be of an integral design.

B1.2 The source assembly, including the source(s), must not be capable of being physically separated from the shielded housing under normal operational, transport or storage conditions.

B1.3 The source(s) must be fixed in the source assembly in such a manner to prevent loss, dislodgment or removal of any of the sources.

B1.4 The gauge must be designed to prevent wear, corrosion, dust, moisture, vibration, heat, or any other external factor, from adversely affecting the integrity of the source encapsulation, source assembly, or source shields, or interfering with the ease of operation of the gauge.

B1.5 The source assembly and retraction mechanism must be designed to prevent jamming or sticking.

B1.6 The source assembly must be capable of being key locked in the shielded position.

B1.7 The source assembly must be capable of being positively located in the:

(a) correct operating position(s); and

(b) shielded position.

B1.8 A mechanical indicator must clearly and unambiguously indicate the source position, by a label or marking, or by the position of the source assembly.

B1.9 All components of the gauge, including the source(s), source assembly and shielding, must be constructed of physically and chemically compatible materials that perform satisfactorily under irradiation conditions.

B1.10 The gauge must be labelled on its exterior surface with a durable label[10] incorporating the:

(a) radiation hazard warning symbol;

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

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

(d) the maximum dose rate at the gauge surface when the source(s) is/are in the shielded position, and the date that this measurement was made;

(e) the name and address of the manufacturer of the gauge;

[10] An example of a suitable label is given in Annex A of the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*.

(f) the serial numbers of the source(s) and the gauge; and

(g) any other information required by the relevant regulatory authority.

B1.11 The gauge must be **durably labelled, marked or engraved** in a conspicuous location on the exterior surface of both the gauge and the transport case with:

(a) the Responsible Person's name or organisation; and

(b) the Responsible Person's full contact telephone number.

B2 SHIELDING REQUIREMENTS

B2.1 When the source(s) is/are in the shielded position, the radiation levels must not result in an ambient dose equivalent rate or directional dose equivalent rate, as appropriate, exceeding:

(a) 250 µSv h^{-1} at any point 0.05 m from the gauge surface; and

(b) 10 µSv h^{-1} at any point 1 m from the gauge surface.

B2.2 The shielding must be designed and constructed to withstand, without loss of shielding integrity, all effects of vibration, resonance or acceleration arising during normal use, storage or transport.

B2.3 The shielding must be designed and constructed to withstand, without loss of shielding integrity, temperatures and pressures arising during normal use, storage and transport.

B2.4 The shielding must be designed and constructed to standards which, from time to time, may be set by the relevant regulatory authority.

Schedule C

Survey Meters

C1 GENERAL REQUIREMENTS OF THE SURVEY METER

C1.1 The radiation survey meter required by clause 4.2.1 must:

(a) have sufficient measurement range to measure ambient dose equivalent rates or directional dose equivalent rates, as appropriate, at least throughout the ranges of 1 $\mu Sv\ h^{-1}$, or its equivalent, to 500 $\mu Sv\ h^{-1}$, or its equivalent, for the radiations emitted from the radioactive sources used in portable density/moisture gauges;

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

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

C2 CALIBRATION OF THE SURVEY METER

C2.1 Radiation survey meters must have an operational and calibration check:

(a) prior to initial use;

(b) at intervals not exceeding 12 months; and

(c) following damage or repairs.

C2.2 The calibration of a radiation survey meter must be, in the case of electromagnetic radiation, traceable to:

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

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

C2.3 Where a neutron survey meter has been obtained, the calibration of that survey meter must be traceable to:

(a) the Australian National Standard for neutron radiation; or

(b) an equivalent overseas National Standard for neutron radiation recognised by the relevant regulatory authority.

Schedule D

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

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	–

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

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

3 (DELETED)

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

5 The equivalent dose limit for the skin applies to the dose averaged over any 1 cm^2 area of skin, regardless of the total area exposed.

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

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

References

Australian Radiation Protection and Nuclear Safety Agency 2001, *Code of Practice for the Safe Transport of Radioactive Material 2001*, Radiation Protection Series No. 2, ARPANSA, Yallambie.

Australian Radiation Protection and Nuclear Safety Agency 2002, *Recommendations for Limiting Exposure to Ionizing Radiation (1995), and National Occupational Health and Safety Commission National Standard for Limiting Occupational Exposure to Ionizing Radiation*, Radiation Protection Series No. 1, republished 2002, ARPANSA, Yallambie.

International Atomic Energy Agency 2000, *Regulations for the Safe Transport of Radioactive Material 1996 Edition (Revised)*, Safety Standards Series No. TS-R-1, IAEA, Vienna.

International Commission on Radiation Units and Measurement 1993, *Quantities and units in radiation protection dosimetry*, ICRU Report 51, International Commission on Radiation Units and Measurements, Bethesda, Maryland.

International Commission on Radiological Protection 1990, *1990 Recommendations of the International Commission on Radiological Protection*, Oxford, Pergamon Press, ICRP Publication 60, Annals of the ICRP Vol. 21 No. 1-3.

Glossary

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).

ALARA

an acronym for 'as low as reasonably achievable', used in the context of optimisation.

ambient dose equivalent, H*(d)

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

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

authorisation

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

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,Ω)

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.

durably labelled, marked or engraved

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

effective dose

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

$$E = \sum_{T} w_T \cdot H_T$$

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

From the definition of equivalent dose, it follows that:

$$E = \sum_{T} w_T \cdot \sum_{R} w_R \cdot D_{T,R}$$

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

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

equivalent dose

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

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

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

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

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

gamma radiation

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

half-life

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

ICRP

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

ICRU

the International Commission on Radiation Units and Measurement.

incident

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

kerma, K

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

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

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

neutron

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

NHMRC

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

radioactive source

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

radioactive substance

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

radiotoxicity

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

relevant regulatory authority

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

Responsible Person

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

(a) having overall management responsibility including responsibility for the security and maintenance of the source, apparatus, or facility; and

(b) having overall control over who may use the source or apparatus, or facility; and

(c) in whose name the source, apparatus, or facility, would be registered if this is required.

routine maintenance

work intended by the manufacturer of the gauge to be performed by the Responsible Person.

service provider

a person who is, or who employs, a **service technician**.

service technician

a person, being a natural person, who repairs, performs maintenance other than routine maintenance or calibrates a portable moisture/density gauge containing radioactive sources.

source assembly

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

source shielding

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

supplier

any person who designs, manufactures, produces, constructs, leases, or hires out a sealed radioactive source or sealed source apparatus. (An importer of a sealed radioactive source or sealed source apparatus is considered a supplier of the source or apparatus.)

Transport Code, the

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

Annex 1

REGULATORY AUTHORITIES

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

COMMONWEALTH, STATE / TERRITORY	CONTACT
Commonwealth	Director, Regulatory Branch ARPANSA PO Box 655 Tel: (02) 9541 8333 Miranda NSW 1490 Fax: (02) 9541 8348 Email: info@arpansa.gov.au
Australian Capital Territory	Manager Radiation Safety Radiation Safety Section ACT Health Locked Bag 5 Tel: (02) 6207 6946 Weston Creek ACT 2611 Fax: (02) 6207 6966 Email: radiation.safety@act.gov.au
New South Wales	Director Radiation Control Department of Environment and Conservation PO Box A290 Tel: (02) 9995 5000 Sydney South NSW 1232 Fax: (02) 9995 6603 Email: radiation@epa.nsw.gov.au
Northern Territory	Manager – Radiation Health Radiation Health Section Department of Health and Community Services GPO Box 40596 Tel: (08) 8922 7489 Casuarina NT 0811 Fax: (08) 8922 7334 Email: envirohealth@nt.gov.au
Queensland	Director, Radiation Health Department of Health 450 Gregory Terrace Tel: (07) 3406 8000 Fortitude Valley QLD 4006 Fax: (07) 3406 8030 Email: radiation_health@health.qld.gov.au
South Australia	Director, Radiation Protection Division Environment Protection Authority PO Box 721 Tel: (08) 8130 0700 Kent Town SA 5071 Fax: (08) 8130 0777 Email: radiationprotection.branch@state.sa.gov.au
Tasmania	Senior Health Physicist Health Physics Branch Department of Health and Human Services GPO Box 125B Tel: (03) 6222 7256 Hobart TAS 7001 Fax: (03) 6222 7257 Email: health.physics@dhhs.tas.gov.au
Victoria	Manager, Radiation Safety Program Department of Human Services GPO Box 4057 Tel: (03) 9637 4167 Melbourne VIC 3001 Fax: (03) 9637 4508 Email: radiation.safety@dhs.vic.gov.au
Western Australia	Secretary, Radiological Council Locked Bag 2006 Tel: (08) 9346 2260 Nedlands WA 6009 Fax: (08) 9381 1423 Email: radiation.health@health.wa.gov.au

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

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

SAFETY GUIDE

Portable Density/Moisture Gauges Containing Radioactive Sources (2004)

Radiation Protection Series Publication No. 5

May 2004

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Contents

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1. Introduction

1.1 Citation

This Safety Guide may be cited as the *Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)*.

1.2 Background

The information contained in this Safety Guide is used to provide practice-specific guidance on achieving the requirements set out in the accompanying *Code of Practice for Portable Density/Moisture Gauges Containing Radioactive Sources (2004)* (hereafter 'the Code').

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

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

1.3 Purpose

The purpose of this Safety Guide is:

- to assist in the development of a Radiation Management Plan that complies with the requirements of Section 2 of the Code; and
- to provide other general safety guidance to assist compliance with the Code.

1.4 Scope

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

2. Work Practices

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

It is a requirement of the Code that the Radiation Management Plan be reviewed and updated at appropriate intervals. The Radiation Management Plan should be viewed as a living document such that as changes occur to equipment, operators or work practices, it should be reviewed or updated to reflect the changing nature of the use of radiation at the practice.

2.1 WORKING RULES

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

(a) the expected radiation levels around each portable density/moisture gauge under the control of the Responsible Person;

(b) the correct and safe methods needed to undertake portable density/moisture measurements on the surface and at various depths using the gauge;

(c) the methods for conducting the radiation surveys, wipe tests and any other examination required by the Code, and for reporting and recording results;

(d) the arrangements for securing the source assembly in the shielded housing and for the security of the gauge;

(e) arrangements for personal monitoring including:

- the personal monitoring service provider;
- type of personal monitor to be worn;
- wearing position;
- requirements for storage of personal monitors when not in use; and
- the storage location of the control monitor,

(f) arrangements for preventing or minimising radiation exposure of operators and members of the public;

(g) steps to be taken in the event of an emergency (see Section 2.2 of this Safety Guide);

(h) any authorisation requirements and conditions of each relevant regulatory authority in whose jurisdiction the gauge will be used;

(i) any special instructions from or requirements of the relevant regulatory authority;

(j) arrangements for the safe storage and transport of the gauge (see Section 5 of the Code);

(k) arrangements for the safe calibration, repair and maintenance of the gauge;

(l) instructions concerning the posting of radiation warning signs (Annex A) when the gauge is in use; and

(m) relevant contact addresses and telephone numbers including:

- the Radiation Safety Officer;
- where relevant, the service provider;
- personal monitoring service provider; and
- relevant regulatory authority, as well as the after hours emergency number.

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

(a) before moving the source from its shielded housing, ensure that all people who are not required to assist with measurements are excluded from the vicinity of the gauge, eg. to a distance of 3 metres;

(b) keep the number of people assisting with the measurement to the absolute minimum;

(c) while a portable density/moisture gauge is in use, the site is appropriately supervised;

(d) always lock the source(s) in the shielded position whenever measurements are not being made;

(e) never move the source(s) from the shielded housing except to make a measurement or to carry out routine maintenance (eg. cleaning of source rod);

(f) only move the source(s) from its housing immediately prior to making a measurement, then immediately return the source(s) to its shielding on the completion of the measurement;

(g) do not waste time while conducting measurements;

(h) do not stay close to the gauge except when necessary to conduct measurements;

(i) never conduct measurements unless those workers directly involved with using the gauge are correctly wearing appropriate personal monitoring devices; and

(j) never place the gauge where vehicles or machinery may damage it.

2.2 EMERGENCY PROCEDURES

Written emergency procedures for inclusion in the Radiation Management Plan should include the following items:

(a) instructions on the immediate actions that need to be taken to protect human life, limit injury and provide first aid where required;

(b) instructions on the immediate procedures needed to bring the incident under control, including details on the action necessary to:

- prevent the further spread of **contamination** (if this possibility arises);
- secure an area of at least 3 metres around any unsecured source(s);
- secure the gauge or sources and to prevent any further damage;
- prevent unauthorised and unnecessary access to the secured area;
- provide or augment shielding against external radiation; and
- allay panic.

(c) instructions for the operator involved to report the incident to the Radiation Safety Officer or the Responsible Person;

(d) instructions for the Radiation Safety Officer to:

- assess the nature and scope of any radiation hazard;
- implement any further action required to bring the incident under control;
- immediately report the incident to the Responsible Person, and to the relevant regulatory authority;
- investigate the circumstances of the incident and undertake assessments, measurements and calculations, in order to determine the optimum corrective action plan and to estimate the doses of the operators and members of the public involved in the incident;
- assemble the necessary resources and implement the required corrective action, taking into account instructions from the Responsible Person and the relevant regulatory authority;
- prepare a detailed report of the incident as soon as possible after the incident and submit this report, within seven days of the incident, to the relevant regulatory authority, through the Responsible Person; and
- advise the Responsible Person and the relevant regulatory authority on changes required to prevent the recurrence of a similar incident.

(e) names, addresses and telephone numbers required in the event of an emergency (these should be checked and updated at least once every 12 months and when changes in arrangements are made); and

(f) any other instructions to cover possible emergencies, such as:

- observed or suspected damage to a source or to a gauge, eg. displacement from a moving vehicle, crushing by a vehicle etc.;
- observed or suspected malfunction of the gauge or the source assembly;
- suspected or actual loss of the gauge or of a source;
- failure of safety procedures or a breach of the working rules; and
- fire, flood, explosion or other disaster or incident.

3. Responsibilities and Duties

Section 2 of the Code requires that roles and responsibilities of Responsible Persons, service providers and operators involved with the use of portable density/moisture gauges be included in the Radiation Management Plan. In addition to the mandatory responsibilities and duties specified in the Code, the following responsibilities and duties for Responsible Persons and duly appointed Radiation Safety Officers should be considered for inclusion in the Radiation Management Plan.

3.1 RESPONSIBILITIES OF THE RESPONSIBLE PERSON

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

Where the Responsible Person is required to provide instruction to personnel, this should be done at the induction of those personnel and at intervals of not greater than 12 months. Instruction might need to be more frequent where there have been changes to legislation or other safety requirements that are relevant to those personnel.

3.2 DUTIES OF THE RADIATION SAFETY OFFICER

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

- Obtain and maintain a knowledge of the principles and practices of radiation protection and of the potential radiation hazards associated with portable density/moisture gauges, sufficient to undertake the measurements, investigations and assessments laid down in the Code and this Safety Guide;
- Be thoroughly familiar with the:
  - (i) requirements of the relevant radiation safety legislation;
  - (ii) provisions of the Code and this Safety Guide;
  - (iii) Radiation Management Plan of the organisation;
  - (iv) detailed working rules and emergency procedures adopted for use in accordance with the Code and this Safety Guide; and
  - (v) radiation survey meters, protective equipment and personal monitoring devices in use to meet the requirements of the Code and this Safety Guide;
- Ensure that, where required by the relevant regulatory authority, personal monitoring devices and radiation survey meters are available and are in good working order;
- Ensure that, where required by the relevant regulatory authority, operators are issued with appropriate personal monitoring devices for

their exclusive use while using, storing, transporting or maintaining portable density/moisture gauges;

- Issue and collect any personal monitoring devices that may be used;
- Seek the advice of the relevant regulatory authority regarding any detailed conditions for use of personal monitoring devices;
- Ensure that personal monitoring devices are promptly submitted for assessment after use;
- Ensure that individual personal monitoring devices known or reasonably suspected to have received a dose in excess of 1 mSv while being worn:
  (a) are assessed promptly; and
  (b) if being returned to a personal radiation monitoring service for assessment, that the service is advised of the circumstances;
- Ensure that individual personal monitoring devices, known or reasonably suspected to have received an unusual dose while not being worn:
  (a) are assessed promptly; and
  (b) if being returned to a personal radiation monitoring service for assessment, that the service is advised of the circumstances;
- Select, with the approval of the relevant regulatory authority, survey meters to meet the requirements of the Code and the Safety Guide; and
- Carry out such extra duties as are necessary to meet the requirements of the Code for storage, emergencies and for transport.

4. Radiation Monitoring and Radiation Levels

In addition to the mandatory requirements for radiation monitoring specified in the Code, the following information should also be considered for inclusion in the Radiation Management Plan.

4.1 MONITORING DEVICES TO BE AVAILABLE

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

4.2 SURVEY METERS

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

The radiation survey meter should be checked against a known radiation source prior to each use to ensure that it is operating in the correct manner. This can be effected by comparing measurements against the known radiation profile of the gauge. Failure to do so may result in personnel being inadvertently exposed to elevated radiation levels where a monitor is malfunctioning or not calibrated.

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

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

Service technicians involved with repair of portable density/moisture gauges might also need to be equipped with a suitable contamination monitor, particularly if they are performing wipe tests. Contamination monitors should also be considered where there is a possibility that a source capsule can become ruptured.

5. Storage and Transport

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

5.1 STORAGE OF GAUGES

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

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

1.	Explosives
2.1	Flammable gas
3	Flammable liquid
4.1	Flammable solid
4.2	Spontaneously combustible
4.3	Dangerous when wet
5.1	Oxidising agent
5.2	Organic peroxide
8	Corrosive

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

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

The name and contact details of the Radiation Safety Officer, or other relevant person, should be placed on the store in a conspicuous location.

5.2 TRANSPORT OF GAUGES

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

Loading restrictions also exist for the transport of portable density/moisture gauges with other dangerous goods with the class restriction being the same as those given for storage as outlined above. The Australian Dangerous Goods Code (ADGC), as amended from time to time, specifies the criteria for the transport of mixed dangerous goods on the one conveyance. The ADGC should be checked before a portable density/moisture gauge is transported with any other dangerous goods on the one conveyance. In general though,

mixing incompatible classes of dangerous goods on the one conveyance would not be permitted unless there is segregation of at least 12 metres and for some mixed classes, 24 metres.

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

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

6. Miscellaneous Audit, Source and Gauge Requirements

The following information should also be considered for inclusion in the Radiation Management Plan.

6.1 RESULTS OF AUDITS

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

6.2 GENERAL RADIOACTIVE SOURCE REQUIREMENTS

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

(a) only incorporate radioactive substances that have the minimum activity and **half-life**, consistent with the projected useful life of the gauge; and

(b) emit radiation of the type and energy appropriate for the particular application.

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

(a) no other suitable lower **radiotoxicity** substance is available; or

(b) the radioactive substance is being used to produce neutrons.

6.3 GENERAL DESIGN REQUIREMENTS OF THE GAUGE

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

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

Annex A

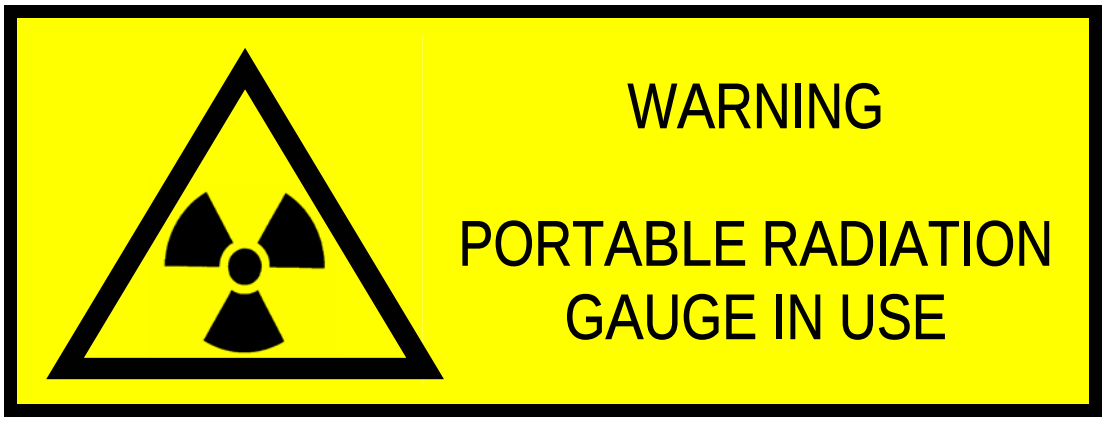
Radiation warning signs and labels

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

COLOURS FOR RADIATION WARNING SIGNS AND LABELS

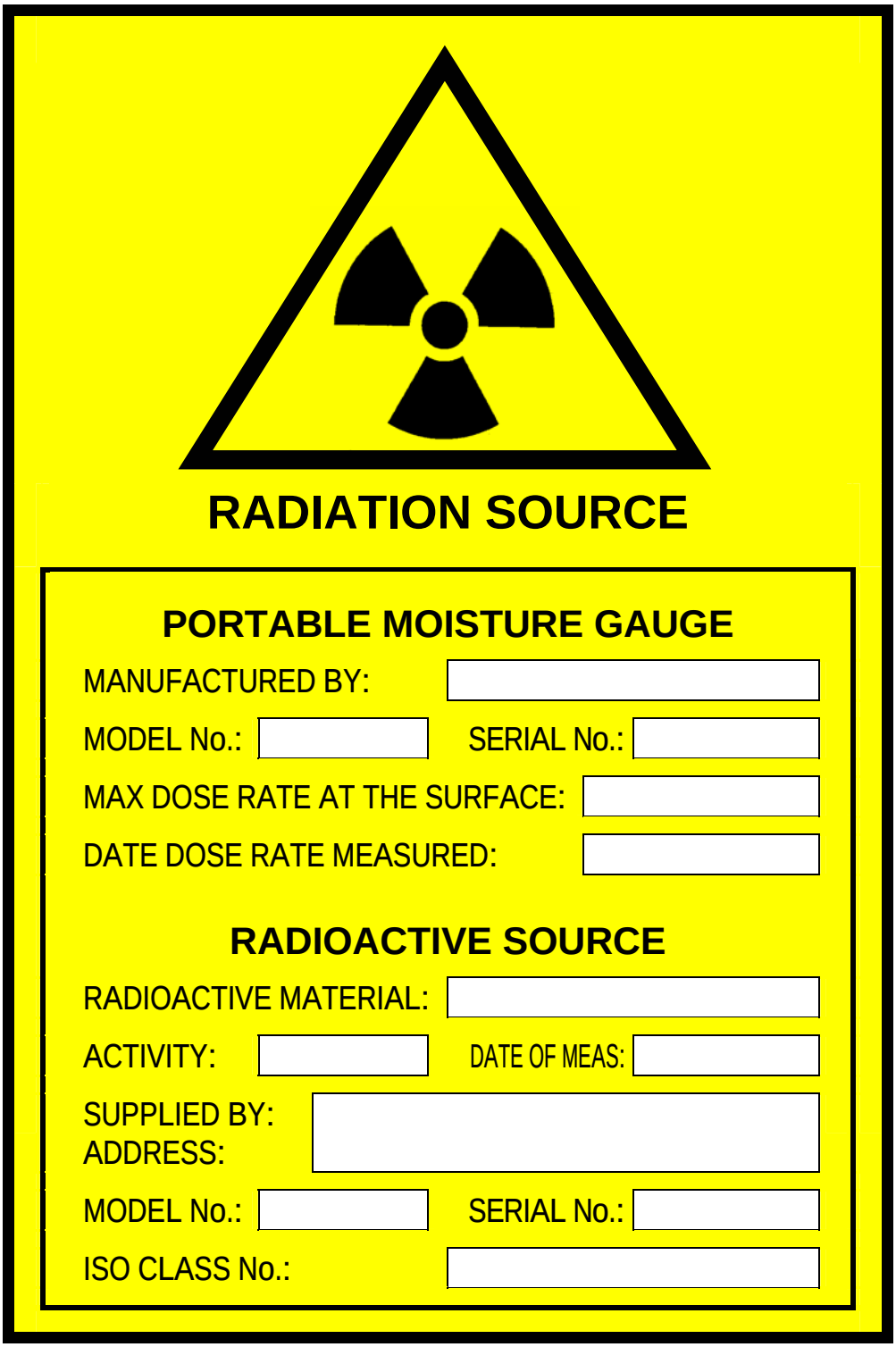
Background:	yellow
Marking and trefoil:	black

EXAMPLE OF A SUITABLE WARNING SIGN FOR POSTING IN THE AREA ADJACENT TO PORTABLE DENSITY/MOISTURE GAUGE WHEN IN USE



EXAMPLE OF A SUITABLE WARNING SIGN FOR A STORE

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



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

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

Annex B

Health Effects of Ionizing Radiation and Standards for Control of Exposure

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

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

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

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

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

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

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

> *Justification*: human activities that cause exposure to radiation may be permitted only if they do more good than harm;
>
> *Optimization of protection*: exposure to radiation from justified activities should be kept as low as reasonably achievable, social and economic factors being taken into account; and
>
> *Limitation of individual dose*: doses must not exceed the prescribed dose limits.

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

Limit on effective dose*

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

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

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

Annual limit on equivalent dose*

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

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

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

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

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

Annex C

ARPANSA Radiation Protection Series Publications

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

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

RADIATION PROTECTION SERIES

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

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

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

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

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

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

RADIATION HEALTH SERIES

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

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

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

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

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

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

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

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

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

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

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

RHS 17. Procedure for testing microwave leakage from microwave ovens (1985)

RHS 18. Code of practice for the safe handling of corpses containing radioactive materials (1986)

RHS 19. Code of practice for the safe use of ionizing radiation in secondary schools (1986)

RHS 20. Code of practice for radiation protection in dentistry (1987)

RHS 21. Revised statement on cabinet X-ray equipment for examination of letters, packages, baggage, freight and other articles for security, quality control and other purposes (1987)

RHS 22. Statement on enclosed X-ray equipment for special applications (1987)

RHS 23. Code of practice for the control and safe handling of radioactive sources used for therapeutic purposes (1988)

RHS 24. Code of practice for the design and safe operation of non-medical irradiation facilities (1988)

RHS 25. Recommendations for ionization chamber smoke detectors for commercial and industrial fire protection systems (1988)

RHS 26. Policy on stable iodine prophylaxis following nuclear reactor accidents (1989)

RHS 28. Code of practice for the safe use of sealed radioactive sources in bore-hole logging (1989)

RHS 29. Occupational standard for exposure to ultraviolet radiation (1989)

RHS 30. Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields (1989)

RHS 31. Code of practice for the safe use of industrial radiography equipment (1989)

RHS 32. Intervention in emergency situations involving radiation exposure (1990)

RHS 34. Safety guidelines for magnetic resonance diagnostic facilities (1991)

RHS 35. Code of practice for the near-surface disposal of radioactive waste in Australia (1992)

RHS 36. Code of practice for the safe use of lasers in schools (1995)

RHS 37. Code of practice for the safe use of lasers in the entertainment industry (1995)

RHS 38. Recommended limits on radioactive contamination on surfaces in laboratories (1995)

ENVIRONMENT PROTECTION (NUCLEAR CODES) ACT SERIES

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

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

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