Code of practice for the safe use of sealed radioactive sources in borehole logging (1989)

RADIATION HEALTH SERIES No. 28

NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL

CODE OF PRACTICE

FOR THE SAFE USE

OF SEALED

RADIOACTIVE SOURCES

IN BOREHOLE LOGGING

(1989)

RADIATION HEALTH SERIES No. 28

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Department of Community Services and Health

1. INTRODUCTION

1.1 General

The use of radioactive sources in borehole logging is governed by regulations under the appropriate radiation control legislation in all States and the Territories. The appropriate statutory authorities responsible for administering this legislation are listed in annexe I to this code.

The radioactive sources used in borehole logging are generally of sufficient activity to constitute a significant health hazard unless adequately shielded and handled with proper care. Under no circumstances shall untrained or inappropriately qualified personnel or unauthorised persons attempt to use, repair or adjust these radioactive sources.

1.2 Purpose and scope

The purpose of this code is to establish working practices, procedures and protective measures which will aid in keeping doses, arising from the use of borehole logging equipment containing sealed radioactive sources, to as low as reasonably achievable and to ensure that the dose-equivalent limits (annexe II), specified in the National Health and Medical Research Council's radiation protection standards (1), are not exceeded.

This code applies to all situations and practices where a sealed radioactive source or sources are used through wireline logging for investigating the physical properties of the geological sequence, or any fluids contained in the geological sequence, or the properties of the borehole itself, whether casing, mudcake or borehole fluids.

Reference to borehole logging equipment shall be taken as to wireline borehole logging equipment configured, or which will be configured by the user, so as to include a radioactive source in the tool string (e.g. gamma-gamma density; apparent hydrogen index through neutron-gamma, neutron-epithermal neutron or neutron-thermal neutron; induced gamma spectrometry), but not including configurations containing only measurement tools with no sources (e.g. natural gamma; natural gamma spectrometry). Self-contained surface or near surface soil density and moisture gauges of integral design, incorporating both the source and instrumentation in a single unit, are the subject of a separate code of practice.

The requirements of this code apply to proven borehole logging equipment. Prototype or research units should comply to the maximum extent possible and should not be constructed or used without special approval from the relevant statutory authority (annexe I).

1.3 Radiation protection standards

Radiation doses considerably exceeding those normally received from natural background radiation are known to cause harm and, in particular, to increase the risk of cancer. It is not known, however, if harmful effects are induced at low doses and low dose rates that are comparable to, or slightly in excess of, background radiation. Because of this it is cautiously assumed that any exposure to radiation may entail some risk and that the risk is proportional to the dose received, down to the lowest dose. Accordingly, limits of radiation dose for persons undertaking work with radiation and radioactive substances are chosen so that the risks arising from the average doses received in that work are no greater than risks in other occupations that have high standards of safety. Likewise, limits of radiation dose for the public are chosen so that the risks to them are no greater than other risks considered acceptable in everyday life. The doses chosen to limit the risks form a set of dose-equivalent limits (annexe II). They have been prepared as radiation protection standards for the National Health and Medical Research Council (NHMRC) which has published them in its *Recommended radiation protection standards for individuals exposed to ionising radiation.* (1) The NHMRC has recommended that these standards be used throughout Australia.

Background information on the biological effects of ionizing radiations is given in annexe III. Further advice on interpretation and application of the standards and dose-equivalent limits is available from the appropriate statutory authority.

The radiation protection standards specify dose-equivalent limits for two categories, viz. radiation workers and members of the public (annexe II).

1.4 Definitions

The specialised terms used in this code are defined in annexe VI.

The words 'shall' and 'should', where used in this code, have specialised meanings. 'Shall' indicates that the particular requirement is considered to be mandatory. 'Should' indicates a requirement that is to be applied, as far as practicable, in the interest of reducing radiation risks.

2. REQUIREMENTS, RESPONSIBILITIES AND DUTIES

2.1 Requirements for suppliers

2.1.1 No supplier shall offer for sale any borehole logging equipment or additional radioactive downhole tools or radioactive calibrators for tools unless that supplier fulfills all requirements of the appropriate legislation. Licensing and/or registration of the supplier, the equipment and personnel employed by the supplier may be required.

2.1.2 The supplier of such borehole logging equipment and sources shall, if required under the direction of the appropriate statutory authority, appoint a Radiation Safety Officer.

2.1.3 Subject to the appropriate legislative and licence provisions, the supplier shall not supply such borehole logging equipment and sources to any person unless that person is licensed under the appropriate legislation.

2.1.4 If the supplier becomes aware of any defect in any model of equipment the supplier shall, without delay, notify the statutory authority, and all purchasers and users supplied with the defective equipment.

2.1.5 The supplier of radioactive sources shall also comply with the appropriate requirements of 3.2.

2.2 Responsibilities of suppliers

Prior to the delivery of borehole logging equipment, the supplier shall:

2.2.1 supply to the appropriate statutory authority, in writing:

(a) name and address of the purchaser or proposed user;

(b) full construction and any test result details of the equipment demonstrating compliance with the requirements of section 3 and including details of the source position and of the shielding provided for the safe storage of the source or sources. This information may only be required for the introduction of a new model;

(c) details of the source type, radioactive substances contained, their activities and dates of assessment,

encapsulation details and copies of the certificates (see 3.2) for each source;

(d) maximum dose rates at distances of 5 cm and 100 cm from the source probe and containers, and details of the dose rates at locations normally occupied by operators during use (note that many neutron survey meters are calibrated to measure dose-equivalent rates directly);

(e) appropriate conversion factors relating the dose-equivalent rate to the dose rate due to the gamma radiation component for each neutron source which has a significant gamma radiation component, including the source and shielding configurations and conditions under which the factors apply; and

(f) other details as required by the statutory authority to assess compliance with the requirements of this code;

2.2.2 ensure that the borehole logging equipment is capable of operating correctly and safely in accordance with the provisions of this. code; and

2.2.3 supply to the purchaser or proposed user all of the relevant information listed in 2.2.1 together with operating and maintenance instructions to permit the equipment to be operated correctly and safely in accordance with the provisions of this code.

2.3 User responsibilities

The user of borehole logging equipment shall:

2.3.1 supply to the appropriate statutory authority, prior to receiving the equipment, information on the equipment's proposed use, storage and transport arrangements together with any other information required and obtain a licence and/or registration as applicable under the appropriate legislation;

2.3.2 prior to the first use of the equipment and at intervals not exceeding three months, ensure that the equipment is examined:

(a) for any damage or excessive wear;

(b) to demonstrate that any source assembly and retraction mechanism operate correctly and safely;

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

(d) to confirm that all labels are still intact, appropriately fitted, and legible (annexe V);

(e) to demonstrate that the dose rates do not exceed those specified in 3.4.1; and

(f) to confirm that measured dose rates do not differ significantly from those expected on the basis of manufacturer's specifications or past experience;

2.3.3 ensure that the equipment is used, transported and stored in accordance with the provisions of this code and only by appropriately qualified and authorised personnel;

2.3.4 ensure that wipe tests of the source(s) and in particular source housing(s) are carried out in the manner and at times which may be specified by the appropriate statutory authority. If not so specified, such wipe tests shall be carried out at least annually;

2.3.5 ensure that if any damage or malfunction occurs which may present a radiological hazard, the statutory authority shall be notified and the unit is not used until it is inspected, repaired and operating correctly and safely in accordance with the provisions of this code;

2.3.6 record and retain the results of all measurements and examinations of the equipment;

2.3.7 formulate working rules specifically for the particular equipment and working situation, including appropriate secure storage (see 5.1);

2.3.8 formulate emergency procedures to minimise radiation exposure in the event of an incident (see 5.2);

2.3.9 ensure that all instrumentation and devices necessary to implement the working rules and the emergency procedures are provided and in good working order;

2.3.10 provide supervision necessary to ensure that employees comply with the working rules and emergency procedures established in accordance with the provisions of this code;

2.3.11 ensure that neither radiation workers nor members of the public receive dose-equivalents exceeding the annual dose-equivalent limits set in the radiation protection standards (1) (annexe II) and that all doses are as low as reasonably achievable;

2.3.12 ensure that all personnel authorised to work with or use the borehole logging equipment 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;

(c) methods to avoid radiation incidents and injuries; and

(d) emergency procedures;

2.3.13 ensure that all radiation warning signs and labels, required in this code, are properly located, fixed and maintained in a clean and legible condition;

2.3.14 appoint a Radiation Safety Officer if the relevant statutory authority so requires. The appointed person shall have sufficient professional and/or technical training to enable ready comprehension and execution of the duties laid down in this code. If a Radiation Safety Officer is not required to be appointed, the user shall undertake the relevant duties;

2.3.15 ensure that the Radiation Safety Officer, if so appointed, undertakes the measurements, investigations and assessments, makes the reports and keeps the records required by this code;

2.3.16 provide the equipment and procedures, and ensure the necessary collaboration with employees so that the Radiation Safety Officer can undertake the measurements, investigations and assessments, make the reports and keep the records required by this code. However, this requirement shall not preclude use, by the Radiation Safety Officer, of outside experts and use of instrumentation not in the possession of the user in accomplishing these duties;

2.3.17 notify the appropriate fire authority and police of the permanent storage locations of all borehole logging equipment containing radioactive sources under his or her control, if required to do so by the relevant statutory authority;

2.3.18 be able to account for all radioactive sources within his or her control at all times;

2.3.19 maintain records which show the following information for all radioactive sources within his or her control:

(a) location and identification numbers;

(b) type of radioactive substances in the sources; and

(c) activities and dates of measurement of the radioactive sources;

2.3.20 not transfer the ownership of any borehole logging source unless this is done with the written approval of the relevant statutory authority;

2.3.21 carry out an annual audit of radioactive sources and of their locations, and send the relevant statutory authority a copy of this audit;

2.3.22 immediately notify the relevant statutory authority if a radioactive source is lost or cannot be accounted for, including sources jammed in boreholes and for which special retrieval methods are required;

2.3.23 provide an itemised account of the loss of any source to the relevant statutory authority, including an account of all recovery procedures and attempts;

2.3.24 ensure that the manufacturers specifications and recommended working limits for the borehole logging equipment are not exceeded (e.g. cables and cable tensioning measuring devices shall be in good operating condition, cableheads shall be properly reterminated at appropriate intervals); and

2.3.25 ensure that radioactive sources or any parts of the radioactive logging configuration necessary for normal retrieval of the source from the hole, which have exceeded their recommended working life, as specified by the manufacture, are not used in borehole logging equipment.

2.4 Duties of Radiation Safety Officer

The Radiation Safety Officer shall:

2.4.1 obtain and maintain a knowledge of the principles and practices of protection against radiation, and of the potential radiation hazards associated with borehole logging equipment, sufficient to undertake the measurements, investigations and assessments laid down in this code;

2.4.2 be thoroughly familiar with the requirements of the relevant radiation safety legislation, the provisions of this code, the radiation monitors and protective devices necessary to meet the requirements of this code. The Radiation Safety Officer should also be responsible for the regular review of such working rules and emergency procedures;

2.4.3 ensure that radiation workers are issued with appropriate personal monitors for their exclusive use whilst using, calibrating, storing, transporting or servicing borehole logging equipment containing radioactive sources (see annexe IV);

2.4.4 ensure that personal monitors and other radiation monitors are issued in good working order;

2.4.5 issue and collect any personal monitors which may be used, and seek the advice of the appropriate statutory authority regarding detailed conditions for use of such monitors;

2.4.6 ensure that personal radiation monitors are promptly returned for assessment after use;

2.4.7 ensure that individual radiation monitors, known or reasonably suspected to have received a dose-equivalent in excess of 1000 μSv per week whilst being worn, or an unusual dose-equivalent whilst not being worn, are assessed promptly. If being returned to a personal radiation monitoring service for assessment, the service shall be advised of the circumstances;

2.4.8 select, with the approval of the statutory authority, survey meters which fulfil the requirements of 4.2; and

2.4.9 carry out such extra duties as are necessary to meet the requirements of 5.2 (emergencies) and 6.2 (transport).

2.5 Employee responsibilities

Employees shall:

2.5.1 acquaint themselves with, and obey, all notices displayed and all instructions issued for their safety and the safety of others;

2.5.2 refrain from careless or reckless practice (including the excessive consumption of alcohol or illicit use of drugs), or action likely to result in a radiation hazard to themselves or others;

2.5.3 use, in a manner required by the statutory authority, devices or instruments furnished to them to assess their personal radiation dose;

2.5.4 not interfere with, remove, alter, damage or render ineffective, any borehole logging equipment or radiation protective device provided to protect the employee or other persons, or interfere with any method or working procedure adopted to reduce radiation exposure, except for authorised purposes of inspection, maintenance, repair, modification or replacement; and

2.5.5 report to the Radiation Safety Officer any difficulties with working procedures or defects in equipment which may have caused or are likely to cause a radiation hazard, including the actual or potential loss of a radioactive source.

3. GENERAL REQUIREMENTS

3.1 General radioactive source requirements

3.1.1 The radioactive sources used in borehole logging shall, where there is a choice, incorporate only radioactive substances which have the minimum activity and halflife consistent with the expected logging to be undertaken.

3.1.2 Only radioactive substances which emit radiation of the type and energy appropriate for the particular application shall be used.

3.1.3 Radioactive substances which are very highly radiotoxic shall not be used unless no other suitable lower radiotoxicity substance is available or unless the radioactive substance is necessary to cause the production of neutrons.

3.1.4 Alpha radiation sources used to cause the production of neutrons shall not contain radium-226 (^{226}Ra) and shall contain americium-241 (^{241}Am) unless an alternative radioactive substance which is approved by the appropriate statutory authority is used.

3.1.5 The radioactive substances shall have physical and chemical properties which minimise corrosion and the build up of internal pressure, and if the source encapsulation is breached, minimise dispersal or dissolution.

3.1.6 A radioactive source which has exceeded its recommended working life, as specified by the manufacturer, shall not be used in borehole logging equipment.

3.2 Encapsulation, packaging and certification of radioactive sources

3.2.1 All radioactive sources supplied for use in borehole logging equipment shall be 'special form radioactive material' as specified in the Australian *Code of practice for the safe transport of radioactive substances 1990*.(2)

3.2.2 The supplier of the radioactive sources shall ensure that the sources are, or have been, tested to demonstrate compliance with the relevant standards and are marked, in the required manner, in accordance with the standards.

3.2.3 The supplier shall also ensure that the radioactive sources are accompanied by all relevant certificates and shall submit copies of any such certificates to the appropriate statutory authority.

3.3 General design requirements of borehole logging equipment

3.3.1 The source holder shall be securely enclosed within a shielded housing under all operational, transport or storage conditions other than those where the probe is deployed in the borehole.

3.3.2 The source shall be fixed and locked in the source holder in such a manner to prevent loss, dislodgement or removal of the source by unauthorised persons.

3.3.3 The borehole logging equipment shall be designed to minimise wear, corrosion, dust, moisture, vibration, heat, or any other external factor from adversely affecting the integrity of the source encapsulation, source holder, source container or shielding, or from interfering with the ease of attachment of the source holder to the tool.

3.3.4 The mechanism for attaching the source holder or subassembly containing the source to the tool shall be designed to be foolproof, protected against unintentional release of the tool and shall be made of wear resistant material.

3.3.5 Where applicable, the source holder shall be positively located in the shielded housing to allow 'hands off' attachment and detachment of spacers and/or tool.

3.3.6 All components of the equipment, including the sources, source assembly and shielding, shall be constructed of physically and chemically compatible materials which perform satisfactorily under irradiation conditions.

3.3.7 In addition to any requirements of the transport code, the source storage/ transport/ container shall be in general compliance with annexe V, figure V.2, and be durably labelled, marked or engraved in a conspicuous location on the exterior surface with:

(a) name of the user or organisation and telephone number;

(b) names of the radioactive substances;

(c) activities of the radioactive substances and the dates of measurement;

(d) maximum dose rate at the shield surface when the sources are shielded and the date this measurement was made;

(e) name and address of the supplier or manufacturer;

(f) identification number of the container and source; and

(g) other information required by the relevant statutory authority.

3.4 Shielding requirements

3.4.1 When the sources are in the shielded storage/ transport containers the dose rates shall not exceed:

(a) 2000 μSv/h at any point 5 cm from the container surface;

(b) 100 μSv/h at any point 100 cm from the container surface; and

(c) such other levels as determined by the appropriate statutory authority.

It should be noted that the units for dose equivalent are used so as to include the quality factor for neutron sources.

3.4.2 The shielded containers shall be designed and constructed so as to meet the requirements of the 1990 transport code (2).

3.4.3 The shielding should be constructed of fire resistant material. Shielding materials which are not fire resistant, such as solid paraffin, shall be used only if enclosed in a fire resistant vessel which will prevent the loss of the shielding material in the event of fire.

4. RADIATION MONITORING AND RADIATION LEVELS

4.1 Monitoring devices to be available

The user of the borehole logging equipment, after seeking advice from the relevant statutory authority, shall ensure that enough radiation monitoring devices, in good condition, are continually available and used in accordance with the following requirements:

4.1.1 film badges, or thermolumines cent monitors (TLDs) available from personal monitoring services in Australia (see annexe IV), or other monitoring devices shall be used for determination of radiation dose received by persons directly involved in using, calibrating or servicing borehole logging equipment. These devices will be referred to collectively as personal monitors. The user should seek the advice of the relevant statutory authority concerning the use of personal dosimeters; and

4.1.2 suitable radiation survey meters shall be available on site to monitor the radiation levels in the vicinity of borehole logging equipment.

4.2 Survey meters

4.2.1 The survey meter shall:

(a) have sufficient measurement range to measure dose rates, at least throughout the ranges of 10 μSv/h or its equivalent, to 10000 μSv/h or its equivalent, for the radiations emitted from the radioactive sources under the control of the user (note that neutron survey meters usually are directly calibrated to measure dose-equivalent rates in μSv/h);

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

(c) indicate, when used to measure gamma radiation, with an uncertainty not greater than $\pm$ 25 per cent, inclusive of uncertainty due to response variation with energy over the range of energies of the radiation to be measured.

4.2.2 Radiation survey meters, referred to in this section, shall be checked and calibrated prior to initial use and at intervals not exceeding 12 months, or following damage or repairs. Calibration certificates will be acceptable to the appropriate statutory authority only when issued by a person or organisation recognised by the relevant statutory authority as competent to do so.

4.2.3 Radiation survey meters sensitive primarily to gamma radiation will not accurately indicate directly the total dose rates in the vicinity of the borehole logging equipment which contain radioactive sources producing neutron radiation. The dose rates measured by gamma survey meters should not be used to estimate the total dose rates unless a suitable conversion factor has been measured and provided by the supplier of the source. The relevant statutory authority should be consulted with respect to such estimations.

4.3 Radiation exposure as a result of an incident

4.3.1 The malfunction of equipment, the failure to observe working rules, the loss of a source or some other cause not within the control of the user and/or employees may result in the exposure of one or more persons to radiation. An unnecessary exposure of personnel may occur prior to the discovery of an incident. If it is known or suspected that a radiation exposure may have occurred as the result of an incident the relevant statutory authority shall be consulted in order to determine an appropriate course of action.

4.3.2 The appropriate statutory authority shall be informed immediately that an incident has occurred and of the steps which have been taken to rectify the situation. Details of any radiation doses known, or suspected to have occurred, shall also be given.

5. SPECIFIC PROCEDURES

5.1 Working rules

The user shall prepare working rules on the safe use of the borehole logging equipment which shall, if required, be submitted to the appropriate statutory authority for approval. These working rules shall include the following points:

5.1.1 correct and safe methods to operate the equipment and undertake logging measurements;

5.1.2 methods for conducting the required radiation surveys, wipe tests and examinations, and for reporting and recording results;

5.1.3 arrangements for securing the source assembly in the shielded transport container and for the security of the equipment;

5.1.4 arrangements for personal monitoring;

5.1.5 arrangements for preventing or minimising radiation exposure of radiation workers and of members of the public;

5.1.6 steps to be taken in the event of an emergency (see 5.2);

5.1.7 clear instructions on safe working practices, which should include the following:

(a) exclude all persons not required to assist with the logging measurements from the vicinity of the equipment prior to removing any source from its shielded transport container;

(b) keep to a minimum the number of people assisting with the operation of the logging equipment while stringing and loading sources;

(c) never conduct logging measurements unless the workers directly involved with using the equipment are correctly wearing appropriate personal monitors and are in possession of a functioning and calibrated survey meter;

(d) never place the equipment where it may be endangered by vehicles or machinery;

(e) never remove the source(s) from the shielded transport container except to make a measurement or to carry out essential servicing;

(f) minimise the time taken whilst transferring the source to and from the shielded transport container and the tool;

(g) stay away from the source except when it is necessary to transfer the source;

(h) unless the condition of the borehole has been well established, a tool incorporating radioactive sources should not be lowered into a borehole unless another tool, which does not contain a source, has freely traversed that depth of the hole to be logged;

(i) radioactive sources should not remain down a borehole any longer than is necessary to carry out the series of measurements required at the time;

(j) always lock the source(s) in the shielded transport container when not in use;

(k) borehole(s) shall be covered at all times while source transfers are carried out above or nearby the borehole(s) to prevent the loss of a source down a borehole; and

(l) instructions regarding appropriate techniques for the care of logging cables, including:

(i) avoidance of kinking and corrosion;
(ii) renewal of cable head termination;
(iii) identification of various cable fault conditions; and
(iv) inspection and replacement intervals;

5.1.8 details of any licence conditions and any special instructions from the statutory authority;

5.1.9 arrangements for the safe storage and transport of the equipment (see 6);

5.1.10 arrangements for the safe calibration, repair and maintenance of the equipment;

5.1.11 instructions concerning the posting of area radiation warning signs (annexe V, figure V.3) when the equipment is in use; and

5.1.12 addresses and telephone numbers of relevant contacts. In the case of equipment transport these addresses and telephone numbers shall be engraved on a fireproof plaque and displayed within the passenger compartment of the transport vehicle.

5.2 Emergency procedures

The user shall, in conjunction with the relevant statutory authority, prepare emergency procedures for use in the event of an incident (see 2.3.8 and 4.3). These emergency procedures should include the following points:

5.2.1 instructions on immediate action to protect human life, to limit injury, and to provide first aid if required;

5.2.2 instructions on immediate procedures to bring the incident under control, including:

(a) action to prevent the spread of contamination e.g. safe source retrieval and containment methods, mud monitoring (if this possibility arises);

(b) action to retrieve and secure the equipment, sources and to prevent any further damage;

(c) action to prevent unauthorised and unnecessary access to the secured area;

(d) action to provide or augment shielding against external radiation; and

(e) action to allay panic;

5.2.3 instructions for the radiation worker involved to report the incident to the Radiation Safety Officer;

5.2.4 instructions for the Radiation Safety Officer to:

(a) assess the nature and scope of any radiation hazard;

(b) implement any further action required to bring the incident under control;

(c) report the incident immediately to the user who shall ensure immediate notification to the relevant statutory authority;

(d) investigate the circumstances of the incident and undertake assessments, measurements and calculations to determine the optimum corrective action plan and to estimate the dose equivalents of the radiation workers and members of the public involved in the incident;

(e) assemble the necessary resources and implement the required corrective action, taking into account instructions from the user and the statutory authority;

(f) prepare a detailed report of the incident for submission by the user, within seven days of the incident, to the relevant statutory authority; and

(g) advise the user on changes required to prevent the recurrence of the incident;

5.2.5 names, addresses and telephone and FAX 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

5.2.6 any other instructions to cover possible emergencies such as:

(a) observed or suspected damage to a source or to the shield housing, e.g. crushing by a vehicle;

(b) observed or suspected malfunction of the equipment's source assembly;

(c) suspected or actual loss of a source;

(d) failure of safety procedures or a breach of the working rules;

(e) the occurrence of a downhole jam; and

(f) fire, flood, explosion or other disaster.

6. STORAGE AND TRANSPORT

6.1 Storage of borehole logging equipment

6.1.1 General storage requirements

That part of the borehole logging equipment which contains the source(s) shall be safely and securely stored when not in use. The following requirements for storage apply:

(a) when in storage the source or source assembly shall be locked in shielded containment;

(b) the equipment shall not be stored near regularly occupied or frequented areas;

(c) the equipment shall not be stored near X-ray or photographic film, explosives, combustibles or corrosive chemicals;

(d) the equipment shall not be stored in other than an approved store for radioactive sources; and

(e) a permanent record of the fact that the equipment is stored, or has been issued, shall be kept by the Radiation Safety Officer or appropriate responsible person.

6.1.2 Permanent store requirements

The permanent store for the borehole logging equipment shall meet the following requirements:

(a) the store shall be constructed of durable materials capable of physically securing the equipment;

(b) the maximum dose rate outside the store shall not exceed 25 μSv/h and in any area which may be occupied by a member of the public, the dose rate and/or occupancy shall be restricted appropriately in order to limit the annual dose to less than 1 mSv;

(c) the store shall be so located to keep the dose rates in any occupied area as low as reasonably achievable;

(d) the store shall be under the control of the Radiation Safety Officer or the user and shall be kept locked; and

(e) the store shall be labelled, in a conspicuous location, with a sign in general compliance with the relevant sign illustrated in annexe V, figure V.4 and which contains the name(s) and telephone number(s) of contact person(s) (i.e. user and RSO).

6.1.3 Field store requirements

When in the field but not in use, the borehole logging equipment shall be stored in accordance with the general storage requirements and with the requirements for the permanent store.

The field store, with the approval of the relevant statutory authority, may be an unoccupied locked motor vehicle parked in such a location to meet the requirements of 6.1.2, or a mobile or temporary structure which meets these requirements.

With the approval of the relevant statutory authority, when a motor vehicle is being used as a field store, the sign specified in 6.1.2 need not be used if the vehicle has been fitted with the warning signs required for transport (annexe V, figure V.5.4).

6.2 Transport of borehole logging equipment

6.2.1 General transport requirements

Equipment shall be transported only in accordance with the requirements of the relevant statutory authority and the Australian *Code of practice for the safe transport of radioactive substances 1990. (2)*

6.2.2 Specific transport requirements

In addition to the general requirements of the 1990 transport code, the following specific requirements apply:

(a) the equipment shall be transported only with the source or source assembly locked into the shielded transport container;

(b) the equipment shall not be transported in the passenger compartment of the transport vehicle and the passenger and equipment compartments shall be

separated by a durable barrier capable of withstanding considerable impact;

(c) when a vehicle is used regularly to transport the equipment, the position of the equipment shall be at the maximum distance from the driver's position and securely fixed in that location;

(d) the transport arrangements shall be such to ensure the security of the equipment at all times;

(e) the transporting vehicle and the equipment shall be fitted with all relevant warning signs and labels required (e.g. these labels and signs are illustrated in annexe V, figures V.5.1 - V.5.4);

(f) a fire resistant metal plaque engraved with the appropriate emergency telephone numbers and other relevant information shall be carried in the passenger compartment of the vehicle;

(g) in the event of an accident or other emergency, the person in charge of the vehicle, or another responsible person, shall notify the user or the Radiation Safety Officer, the nearest police station and the relevant statutory authority; and

(h) all radioactive sources shall be removed from the vehicle and held in a permanent store and all warning signs covered or removed when the vehicle is serviced or repaired.

7. REPAIRS, MAINTENANCE AND DISPOSAL

7.1 Repairs and maintenance

7.1.1 Repairs and maintenance of those parts of the borehole logging equipment which contains a radioactive source(s) shall be carried out only by persons specifically approved and licensed by the statutory authority and in workshops equipped with the appropriate shielding and remote handling equipment to permit safe repair.

7.1.2 The person undertaking the repairs and maintenance work shall keep records in accordance with any instructions which the relevant statutory authority may issue.

7.2 Disposal (including resale)

The user shall not dispose of any borehole logging equipment containing a radioactive source(s) without the approval of the relevant statutory authority.

References

1. National Health and Medical Research Council 1981, *Recommended radiation protection standards for individuals exposed to ionising radiation,* AGPS Canberra, with amendments (1985) and (1988)

2. Dept. of the Arts, Sport, the Environment, Tourism and Territories 1990, *Code of practice for the safe transport of radioactive substances* AGPS Canberra.

3. ICRP 1977, *Recommendations of the International Commission on Radiological Protection,* ICRP publication 26, Pergamon Press, Oxford *(Annals of the ICRP 1, 3).*

ANNEXE I - Statutory authorities

In parts of this code reference is made to the appropriate statutory authority. The appropriate contacts for matters relating to the statutory requirements of the authorities in the States and Territories are:

1. AUSTRALIAN CAPITAL TERRITORY

Director
Radiation Safety Section
ACT Board of Health
GPO Box 825
CANBERRA ACT 2601

Telephone: (06) 247 2899
Fax: (06) 257 3503

2. NEW SOUTH WALES

Officer-in-Charge
Radiation Health Services
Department of Health
PO Box 162
LIDCOMBE NSW 2141

Telephone: (02) 646 0222
Fax: (02) 646 0333

3. NORTHERN TERRITORY

Senior Health Physicist
Environmental Health and
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South Australian Health Commission		
PO Box 6, Rundle Mall		
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Department of Health	Fax:	(002) 310735
GPO Box 191B		
HOBART TAS 7001		

7. VICTORIA

Chief Radiation Officer	Telephone:	(03) 616 7084
Radiation Safety Section	Fax:	(03) 616 7147
Health Department Victoria		
GPO Box 4003		
MELBOURNE VIC 3001		

8. WESTERN AUSTRALIA

The Physicist-in-Charge	Telephone:	(09) 389 2261
Radiation Health Section	Fax:	(09) 3811423
Health Department of Western Australia		
GPO Box X2307		
PERTH WA 6001		

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

ANNEXE II - Annual dose-equivalent limits *

Annual dose-equivalent limits (mSv): whole body
The annual dose-equivalent limits for the whole body are defined for stochastic effects only.

Radiation worker 50 [(a)]
Member of public [(b)] 1[(c)]

Derived annual dose-equivalent limits (mSv): body organs or tissues when irradiated singly.

The derived annual dose-equivalent limit, for any part of the body listed, is taken as the stochastic or non-stochastic limit, whichever is the lower. The higher value is therefore shown in brackets as a reminder that it should not be used as the limit in practice[(d)].

	Radiation worker		Member of the public[(b)]	
Part of body	Stochastic	Non-stochastic	Stochastic	Non-stochastic
gonads	200	(500)	20	(50)
breast	333	(500)	33	(50)
red bone marrow	417	(500)	42	(50),
lung	417	(500)	42	(50)
thyroid	(1670)	500	(167)	50
bone surfaces	(1670)	500	(167)	50
lens	-	150	-	15
other single organ	(833)	500	(83)	50
skin	-	500	-	50
hands and forearms	-	500		50
feet and ankles	-	500		50

Notes

(a) This limit applies both to uniform irradiation of the whole body and to the weighted mean of the doses to individual tissues. For external irradiation, when the dose distribution is unknown, the limit applies to the deep dose-equivalent index.

(b) No dose-equivalent limits are recommended for populations but application of the dose-equivalent limits for individuals, as well as observance of the principles underlying the determination of radiation protection standards*, is likely to ensure that the average dose equivalent to a population will not exceed 0.5 mSv per year.

(c) As exposures at the dose-equivalent limits are not likely to be repeated over many years, a subsidiary limit of 5 mSv per year is allowed for a number of years provided that the lifetime dose to a member of the public will not exceed mSv per year.

(d) For example, the weighting factor for the thyroid is 0.03. Therefore, the implied limit for the thyroid would be 50/0.03 = 1670 mSv, but as this exceeds 500 mSv, it is discarded and the limit 500 mSv used instead.

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* For full details refer to the radiation protection standards (1) and to the International Commission on Radiological Protection publication No. 26 (3).

ANNEXE III - Biological effects of ionizing radiations and limits on exposure to such radiations

Note: This statement provides background information.
Not all of it is relevant to this code.

Considerable knowledge has been gained, particularly during the past three decades, on the biological effects of ionizing radiation on humans. When such effects are manifested in the exposed individual they are referred to as somatic effects; when they arise in the descendants of the exposed individual, they are referred to as hereditary effects. It is important to recognise, however, that many biological effects may occur spontaneously or can be caused by ionizing radiation or by exposure to other agents and it is not always possible to determine the cause of an effect.

Humans have always been exposed to radiation from terrestrial sources, from cosmic radiation and from radionuclides deposited in the body. This natural background radiation varies from place to place, but generally results in individuals receiving about 2 millisievert (mSv)* per year on average, although there are a few places where the terrestrial levels are much higher. The levels of exposure are such that it is not possible to ascribe any of the ill-effects in humans specifically to natural background radiation. However, radiation-induced effects have been observed in individuals who have been exposed to very large doses. It is from such doses that our knowledge of biological effects is derived.

Injury to tissue became evident in the past from a number of different sources. For example, many workers developed bone sarcoma as a result of using radium luminous compounds for painting dials on watches and instruments; some miners working in uranium mines developed lung cancer; some radiologists developed skin erythema and leukaemia because they did not use adequate protection, and there was a small excess of leukaemia and other malignant diseases above the normal incidence rates among survivors of the atomic bombs in Hiroshima and Nagasaki in Japan.

In all these examples, and there are many more demonstrated radiation-induced effects, the doses received by individuals were very large - many times greater, than the doses arising from natural background radiation.

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* The sievert is the unit used in radiation protection for dose equivalent and is equal to 100 rem. 1 mSv = 10^{-3} Sv; 10 mSv = 1 rem.

The effects arising from large radiation doses are well known. However, it has not been possible to obtain any correlation between radiation-induced effects and small doses because of the low numbers of human cases available to provide adequate statistics. Accordingly, studies have been carried out to determine if there is any correlation between effects and dose delivered and dose rate in plants and animals. It has been shown that the incidence of many biological effects produced is related to the total dose delivered, whilst for other effects, there appear to be threshold doses below which those effects may not occur. Although it is not possible to extrapolate the results of these studies to humans, they serve a very useful purpose in identifying possible dose-effect relationships.

The effects arising from exposure to ionizing radiation fall into two categories: stochastic and non-stochastic effects. Stochastic effects are those for which the probability of an effect, but not its severity, is regarded as a function of the dose to which the individual is exposed. It is considered that there is no threshold dose below which the probability of such an effect occurring is zero. Non-stochastic effects are those for which the severity of the effect varies with the dose to which the individual is exposed. A threshold may exist, below which such an effect does not occur.

From the studies undertaken it is believed that the induction of malignancies, including leukaemia, is a stochastic effect of radiation. Such malignancies may not become manifest until many years after the radiation exposure. Mutagenic effects are also stochastic effects and may be propagated through the population for many generations. Defects arising from such mutations are more likely to become apparent in the first or second generation. A defect which causes slight physical or functional impairment, and which may not even be detectable, would tend to continue in the descendants, whereas a severe defect will be rapidly eliminated by the early death of the zygote or of the individual carrying the defective gene. The risk of mutagenic effects arising will decrease with increasing age of the irradiated individuals due to their decreasing child expectancies with age.

Non-stochastic effects are specific to particular tissues; for example, non-malignant damage to the skin, cataract of the eye, gonadal cell damage leading to impaired fertility etc. For many of these, a minimum or threshold dose may be required for the effect to be manifest. If an individual receives a dose greatly in excess of the threshold, manifestation of the effect will occur in a relatively short period. However, if the dose is not greatly in excess of the threshold, many effects will be temporary and reversion to normal conditions usually occurs.

From our knowledge of biological effects arising from exposure to radiation, it is possible to identify the risks of stochastic effects for the

various organs and tissues of the body. These risks are derived from exposure of persons to very high doses and from studies on animals, etc. As there is very little information on the effects of exposure to low doses, it is cautiously assumed that risk is directly proportional to dose, right down to zero dose, and that there is no threshold below which these effects do not occur. These assumptions may lead to overestimates of the risks associated with exposure to low doses of radiation. Although the risks derived from such assumptions may be very small, it is important that they are kept As Low As Reasonably Achievable (referred to as the ALARA principle) and that there be a demonstrated net benefit for each exposure.

Radiation protection is concerned with the protection of individuals in practices which involve radiation exposure, as well as with the protection of members of the public. It recognises that many practices involving radiation exposure are necessary for the well-being of individuals and for the good of mankind, but the doses resulting from those practices must be minimised in accordance with the ALARA principle. Good radiation protection practice requires the setting of standards for occupational exposure. These are such that the risk of fatalities from radiation-induced malignancies resulting from the average doses received in such practices is no greater than the risk of fatalities in other occupations that have high standards of safety. Radiation protection standards were prepared for the National Health and Medical Research Council (NHMRC) in 1980 for use in Australia and are based on the recommendations of the International Commission on Radiological Protection. The standards assume, for stochastic effects, a linear relationship between risk and dose and that there is no threshold below which effects do not occur. For nonstochastic effects the standards set a limit on the dose received, below which such effects would not be manifest in an organ. The limit to be used for an organ is the lower dose limit of that for stochastic effects and that derived for non-stochastic effects when that organ is the only one irradiated.

For purposes of radiation protection the limits given in the standards are specified in terms of annual dose-equivalent limits. For whole body exposure the annual limit for radiation workers is 50 mSv (or 50,000 μSv). In certain circumstances, it is possible that only partial exposure of the body or of a single organ occurs. In these circumstances, limits are prescribed so that the risks are the same as those for uniform whole body exposure. Accordingly, higher dose limits are prescribed when only part of the body is exposed.

When exposure is only from external sources, the doses received can be determined by personal monitors. As they record only the dose received at the point of wearing, the dose to the whole body or to specific organs cannot be easily determined. However, if the monitor is worn on the body in the position most likely to receive the highest

dose, and if the total of monitor doses for an individual in a year does not exceed 50 mSv, the dose-equivalent limits for the whole body and for the various organs will not be exceeded.

Although the standards prescribe dose limits on an annual basis, it is desirable that doses do not exceed 1000 μSv per week (or 4000 μSv per four-weekly period). It will then become obvious during a year if there is any likelihood of the annual limits either being approached or exceeded.

Doses from natural background radiation and from undergoing radiological procedures (i.e. medical and dental X-ray examination, radiotherapy and nuclear medicine) are not to be included in determining occupational doses. Limits are not set for emergency or accidental exposures, but attempts must be made to assess the dose equivalents received as carefully and as quickly as possible so that remedial action can be taken.

The radiation protection standards do not make any special provisions for females of reproductive capacity. However, they state that when a pregnancy is confirmed (normally within two months), arrangements should be made to ensure that the woman works only under such conditions that it is most unlikely that doses received during the remainder of the pregnancy would exceed three-tenths of the pro-rata annual dose-equivalent limits for occupationally exposed persons.

For members of the public, the principal annual limit of effective dose equivalent is 1mSv, not including natural background radiation or radiation received as a patient undergoing radiological procedures. A subsidiary limit of 5mSv in a year is permissible for some years, provided that the average annual effective dose equivalent over a lifetime does not exceed 1mSv. The non-stochastic dose equivalent limit for the skin and the lens of the eye is 50mSv in a year.

References

International Commission on Radiological Protection 1977, *Recommendations of the International Commission on Radiological Protection,* ICRP Publication 26, Pergamon Press, Oxford *Annals of the ICRP 1, 7.*

National Health and Medical Research Council 1981, *Recommended radiation protection standards for individuals exposed to ionising radiation,* AGPS Canberra.

ANNEXE IV - Personal monitoring services within Australia

Personal monitoring services within Australia are operated by the following organisations:

1.	Australian Radiation Laboratory Lower Plenty Road YALLAMBIE VIC 3085	Telephone Fax:	(03) 4332211 (03) 4321835
2.	Radiation Health Services Department of Health PO Box 162 LIDCOMBE NSW 2141	Telephone Fax:	(02) 6460222 (02) 6460333
3.	Division of Health and Medical Physics Department of Health 450 Gregory Terrace FORTITUDE VALLEY QLD 4006	Telephone Fax:	(07) 2525446 (07) 2529021
4.	The Physicist-in-Charge Radiation Health Section Health Department of Western Australia GPO Box X2307 PERTH WA 6001	Telephone Fax:	(09) 3892261 (09) 3811423

Users in other States should seek advice from their local statutory authority.

ANNEXE V - Radiation warning signs and labels

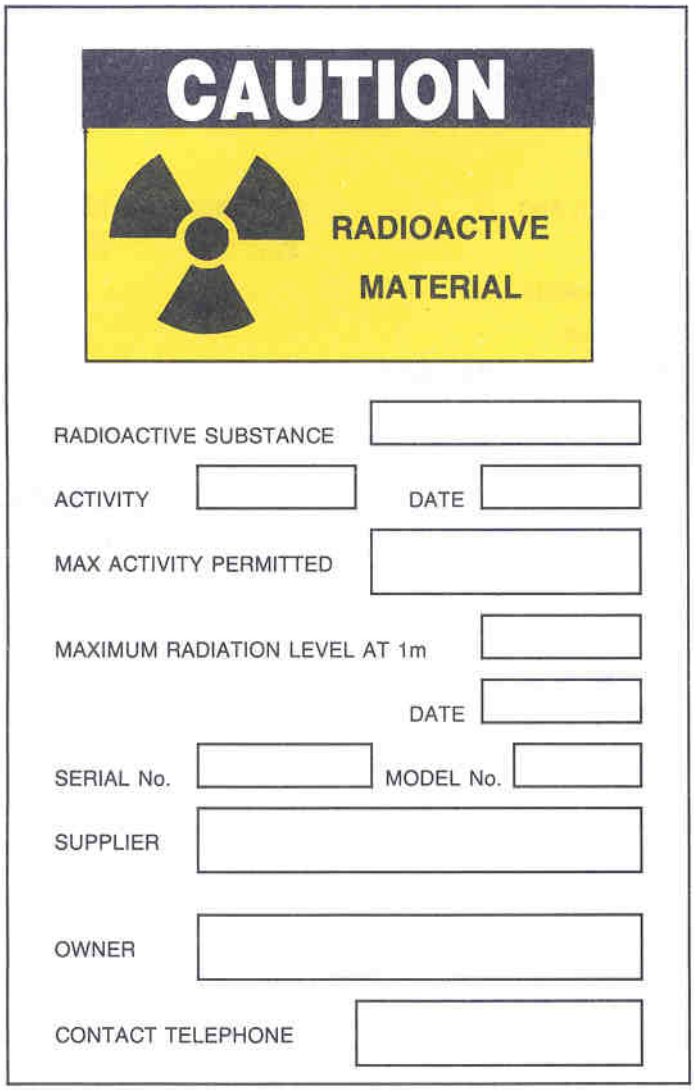
V.1 Colours for radiation warning signs and labels

Background : yellow

Lettering and trefoil : black

(NOTE: in sign V.2 lower part may be unpainted metal with lettering in black)

V.2 Example of label suitable for attachment to borehole logging equipment

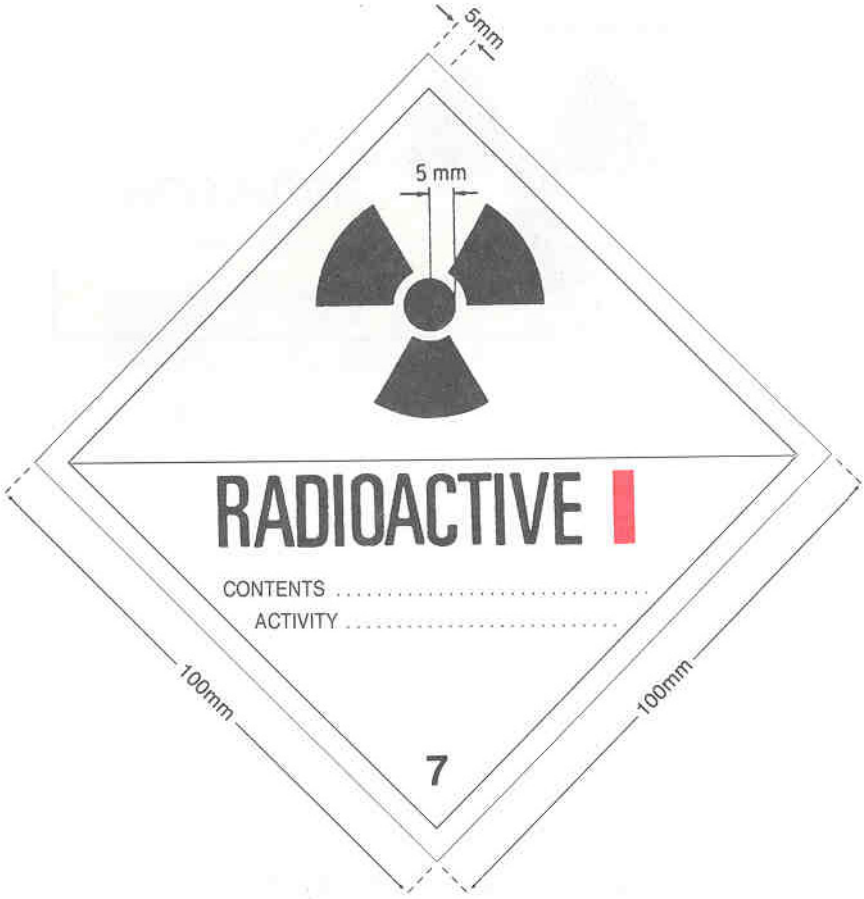


V.3 Example of sign for posting in vicinity (e.g. 5 m radius) of borehole logging equipment when in use

V.4 Example of a suitable sign for a store

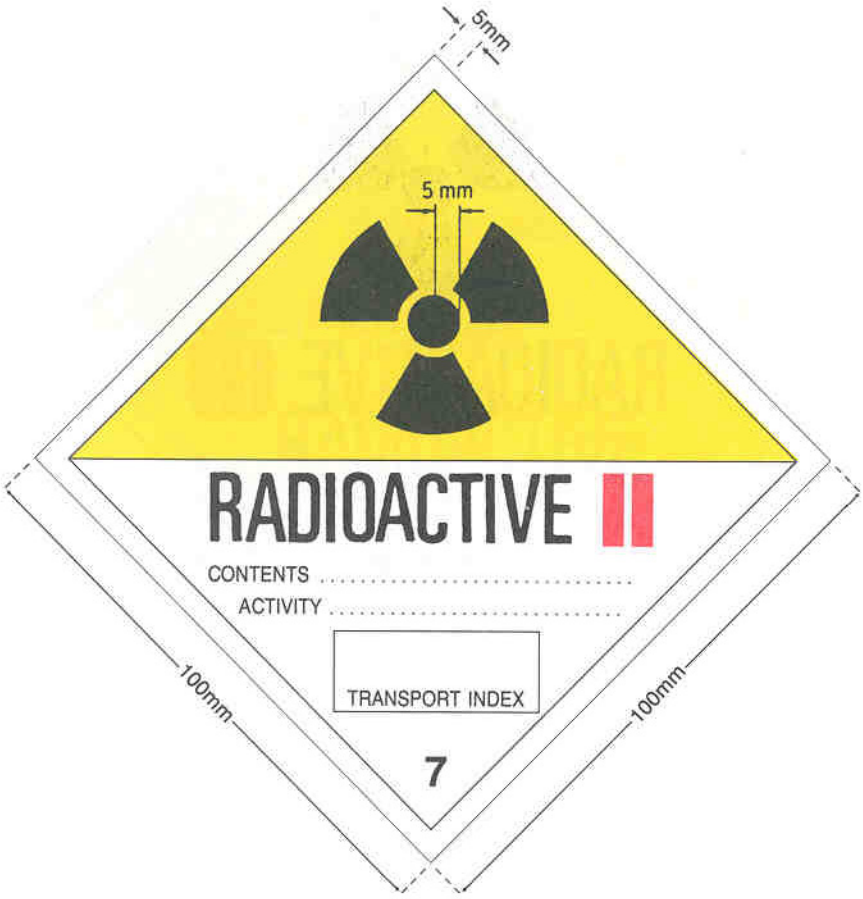
V.5 Examples of labels and signs required for transport

Refer to the Code of practice for the safe transport of radioactive substances 1990 (2) for full details.



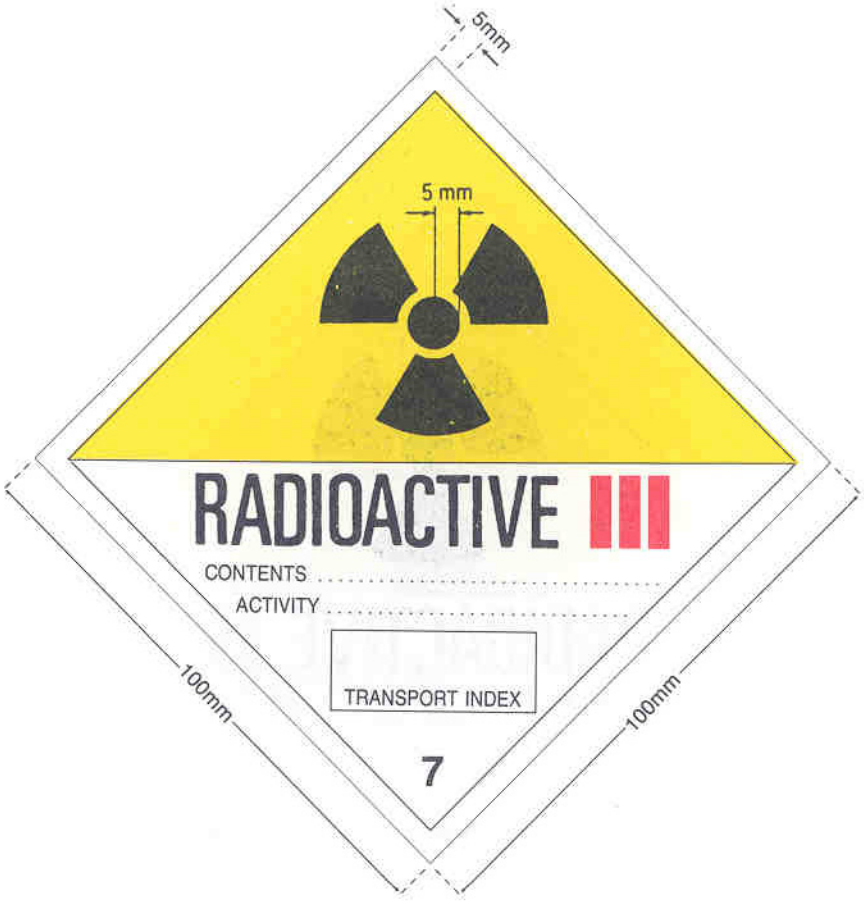
V.5.1 Category I - WHITE label

The background colour of the label shall be white, the colour of the trefoil and the printing shall be black, and the colour of the category bar shall be red.



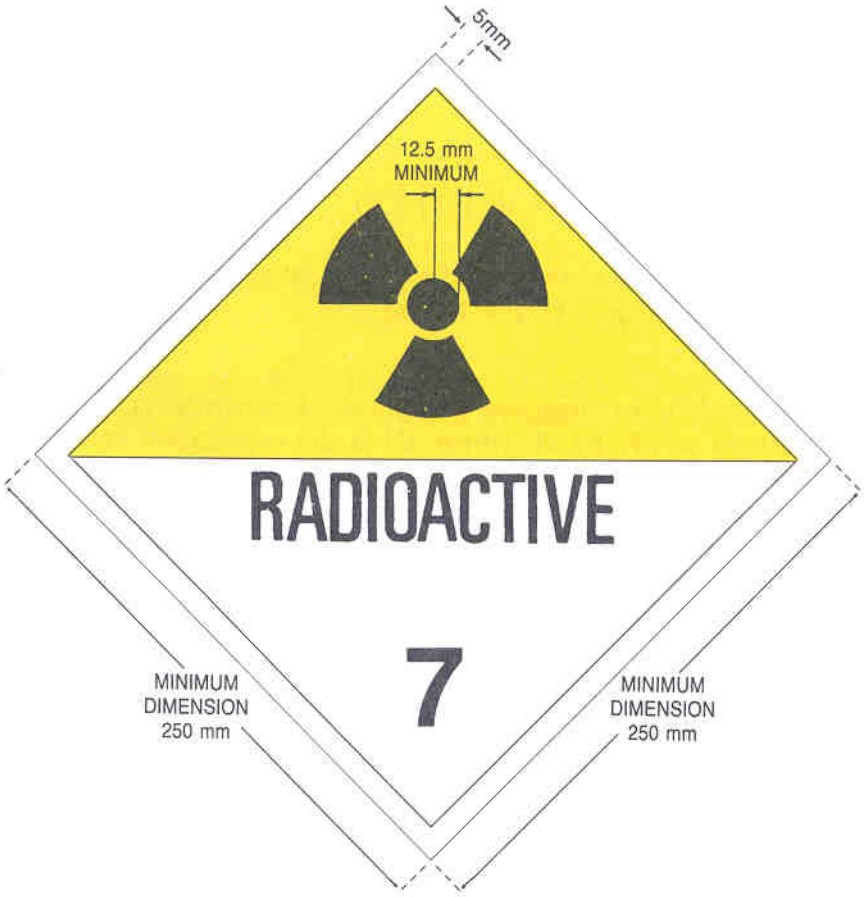
V.5.2 Category II YELLOW label

The background colour of the upper half of the label shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.



V.5.3 Category III - YELLOW label

The background colour of the upper half of the label shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.



V.5.4 Placard for vehicles

Minimum dimensions are given; when larger dimensions are used the relative proportions must be maintained. The figure 7 shall not be less than 25 mm. high. The background colour of the upper half of the placard shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black.

ANNEXE VI - Definitions

Absorbed dose (or dose)

The absorbed dose (D) is the quotient of dE by dm, where dE is the mean energy imparted by ionizing radiation to matter of mass dm.

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

The unit of absorbed dose is the gray (Gy).

$$1\ Gy = 1\ J\ kg^{-1}$$

This replaces the rad as the unit of absorbed dose.

$$1\ rad = 10^{-2}\ J\ kg^{-1};\ 1\ Gy = 100\ rad$$

Activity

The activity (A) of radioactive substance in a particular energy state is the quotient of dN by dt, where dN is the expectation value of the number of spontaneous nuclear transitions from that energy state in the time interval dt.

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

The unit of activity is the becquerel (Bq).

$$1\ Bq = 1\ s^{-1}$$

This replaces the curie as the unit of activity.

$$1\ Ci = 3.7 \times 10^{10}\ s^{-1};\ 1\ Bq = 2.7 \times 10^{-11}\ Ci$$

Capsule

A sealed envelope of metal or other suitable material that may be used to enclose a quantity of a radioactive substance. This envelope may incorporate a means of attachment to the source assembly of the borehole logging equipment.

Container (storage/ transport)

A shielded container used for the storage and transport of radioactive sources.

Contamination

Undesirable material in unsealed gaseous, liquid or particulate form in air, water or other substances, or on surfaces.

Dose-equivalent

The dose-equivalent (H) is the product of D, Q and N at the point of interest in tissue where D is the absorbed dose, Q is the quality factor and N is the product of all other modifying factors.

$$H = DQN$$

The unit of dose-equivalent is the sievert (Sv).

$$1\ Sv = 1\ J\ kg^{-1}$$

This replaces the rem as the unit of dose-equivalent.

$1 \text{ rem} = 10^{-2} \text{ J kg}^{-1}$; 1 Sv = 100 rem

Durably marked

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.

Gamma radiation

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

Gamma source

A radioactive source that emits gamma radiation.

Half-life

For a single radioactive decay process, the time required for the amount of a radioactive substance to decrease to one-half of its original value.

Incident

An unintended occurrence involving a radioactive source, the borehole logging equipment, or the persons, or objects surrounding the radioactive source, that may result in one or more persons receiving a dose of radiation.

Members of the public

All persons who are not classified as radiation workers.

Neutron

Electrically neutral particle having approximately the mass of a hydrogen atom and which forms part of the nucleus of most atoms.

Neutron source

A radioactive source that emits neutron radiation.

Radiation workers

Persons who, in the course of their employment, may be exposed to ionizing radiation arising from their direct involvement with sources of such radiation.

Radioactive decay

The process in which the nuclei of the atoms in a radioactive material either undergo spontaneous transformation into other atoms or in which there are spontaneous changes in the energy level of the nuclei.

Radioactive source

For the purpose of this code, a radioactive source is a sealed (radioactive) source, and means a radioactive substance sealed in a capsule or having a bonded cover, with the capsule or cover being strong enough to prevent contact with or the dispersion of the substance under the conditions of the use and wear for which it was designed.

Radioactive substance

Material that undergoes spontaneous transformation of its nucleus with the emission of ionizing radiation, and which for the purposes of this code, exceeds a prescribed concentration or activity.

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.

Shielded housing

That component of the borehole logging equipment which provides protective shielding from the radioactive source during its transfer between or deployment in the storage/ transport container and the borehole.

Source assembly

The source assembly is the component of the borehole logging equipment into which the radioactive source(s) are permanently fixed.

Source shielding

The source shielding is 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

A person or organisation that transfers borehole logging equipment or radioactive source(s) to another person or organisation.

User

A person having administrative responsibility for the use of a particular radioactive source. This person may be the owner of the radioactive source or a person nominated by the organisation that owns the radioactive source.

RADIATION HEALTH SERIES

No. 1. Recommended Radiation Protection Standards for Individuals Exposed to Ionising Radiation (1980)

No. 2. Code of Practice for the Design of Laboratories Using Radioactive Substances for Medical Purposes (1980)

No. 3. Code of Practice for the Safe Use of Ionizing Radiation in Veterinary Radiology: Parts 1 and 2 (1982)

No. 4. Code of Practice for the Safe Use of Radiation Gauges (1982)

No. 5. Recommendations Relating to the Discharge of Patients Undergoing Treatment with Radioactive Substances (1983)

No. 6. Code of Practice for the Safe Use of Lasers in Secondary Schools (1983)

No. 7. Guidelines for the Safe Use of Lasers in the Entertainment Industry (1983)

No. 8. Code of Nursing Practice for Staff Exposed to Ionizing Radiation (1984)

No. 9. Code of Practice for Protection Against Ionizing Radiation Emitted from X-Ray Analysis Equipment (1984)

No. 10. Code of Practice for the Safe Use of Ionizing Radiation in

Veterinary Radiology: Part 3 - Radiotherapy (1984)

No. 11. Code of Practice for the Safe Use of Soil Density and Moisture Gauges Containing Radioactive Sources (1984)

No. 12. Administration of Ionizing Radiation to Human Subjects in Medical Research (1984)

No. 13. Code of Practice for the Disposal of Radioactive Wastes by the User (1985)

No. 14. Recommendations for Minimising Radiological Hazards to Patients (1985)

No. 15. Code of Practice for the Safe Use of Microwave Diathermy Units (1985)

No. 16. Code of Practice for the Safe Use of Shortwave (Radiofrequency) Diathermy Units (1985)

No. 17. Procedure for Testing Microwave Leakage from Microwave Ovens (1985)

RADIATION HEALTH SERIES cont.

No. 18. Code of Practice for the Safe Handling of Corpses Containing Radioactive Materials (1986)

No. 19. Code of Practice for the Safe Use of Ionizing Radiations in Secondary Schools (1986)

No. 20. Code of Practice for Radiation Protection in Dentistry (1987)

No. 21. Statement on Cabinet X-Ray Equipment for Examination of Letters, Packages, Baggage, Freight and Other Articles for Security, Quality Control and Other Purposes (1987)

No. 22. Statement on Enclosed X-Ray Equipment for Special Applications (1987)

No. 23. Code of Practice for the Control and Safe Handling of Radioactive Sources Used for Therapeutic Purposes (1988)

No. 24. Code of Practice for the Design and Safe Operation of Non Medical Irradiation Facilities (1988)

No. 25. Recommendations for Ionization Chamber Smoke Detectors for Commercial and Industrial Fire Protection Systems (1988)

No. 26. Policy on Stable Iodine Prophylaxis Following Nuclear Reactor Accidents (1989)

No. 27. Australia's Radiation Protection Standards (1989)

No. 28. Code of Practice for the Safe Use of Sealed Radioactive Sources in Borehole Logging (1989)

No. 29. Occupational Standard for Exposure to Ultraviolet Radiation (1989)

No. 30. Interim Guidelines on Limits. of Exposure to 50/60 Hz Electric and Magnetic Fields (1989)

No. 31. Code of Practice for the Safe Use of Industrial Radiography Equipment (1989)