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CODE OF PRACTICE

SAFE USE OF IONIZING RADIATION

Prepared by OHS Section
Corporate Services Department
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CONTENTS

PREFACE

Ionizing radiation is used extensively in the field of scientific research. The risk of uncontrolled exposure to both the worker and the environment is ever present.

The purpose of this Code is to set out practices considered by the CSIRO Health and Safety Committee to be appropriate for CSIRO staff and, if followed, they will result in appropriate protection for research staff and the environment. The Code does not cover sources of non–ionizing radiation such as microwave ovens, RF generators and laser sources.

Throughout the Code the terms "shall" and "will" are used where requirements are mandatory and "should" and "may" are used to suggest or recommend the adoption of a practice which would ensure that an acceptable level of radiation safety measures was in place in the event of a legal challenge.

N K Boardman
Chief Executive

SECTION 1 - APPLICATION OF LEGISLATION

General

1. The CSIRO OH&S policy statement (PC 85/12) states interalia:-

> "In the absence of appropriate Commonwealth legislation, it is the Organisation's aim to conform to the standards prescribed by the laws of the State or Territory in which each site or location is situated".

2. There is currently no generally applicable Commonwealth legislation covering the use of ionizing radiation in research establishments. Each State and Territory has a Radiation Safety Act or Ordinance and each CSIRO site will conform to the standards required in that legislation (see Appendix A for List.) as well as to the requirements of this Code.

Most of the State Acts seek to bind "the Crown". The State and Commonwealth have differing views on whether this means "State Crown" or "Commonwealth Crown". The degree to which CSIRO may be legally bound by the State requirements is unclear. The ACT ordinance and NT Act are binding on the Organisation.

Common law action

The misuse of radioactive materials or irradiating apparatus can lead to common law claims involving both the Organisation and individual staff members. Common law action could have serious consequences for the Organisation from both a financial and corporate image perspective.

Defence against a common law claim is enhanced if the Organisation and/or individual can demonstrate that:

- dangers associated with the misuse of radioactive materials or irradiating apparatus were not only recognised but conveyed to those involved in their handling and use;
- safe work practices and conditions were in place;
- there was compliance with relevant State or Territory laws; and
- there was compliance with international and national codes upon which Australian legislation is based.

SECTION 2 – REGISTRATION AND LICENSING

State and Territory legislation sets out requirements for registration and licensing of premises, staff, apparatus and substances. Each CSIRO site will apply for registration and licences, pay relevant fees and will comply with local legislation before commencement of work involving ionizing radiation.

Visiting scientists, honorary fellows and guest workers required to work with radioactive substances or irradiating apparatus shall conform with local legislation and the requirements of this Code of Practice.

In collaborative ventures with private companies or other organisations, the responsibilities for radiation safety and licensing should be documented in Agreements.

Advice should be sought from the relevant State or Territory radiation safety authority if there are doubts concerning the need for or type of licence.

Premises and apparatus should be registered under the position/title of the Chief or OIC for that particular site – unless the local legislation expressly requires otherwise.

Legal responsibilities of staff

At common law an employer is responsible for the action of employees but this does not absolve individual staff members from responsibility toward their colleagues and the general public. Persons working with irradiating apparatus or radioactive materials shall strictly observe guidelines for exposure limits to radiation. The International Commission for Radiological Protection has set the following essential criteria.

- no practice involving radiation exposure shall be adopted unless its introduction produces a net benefit;
- exposures should be kept As Low As is Reasonably Achievable taking economic and social factors into account (the ALARA principle); and
- the dose equivalent for individuals shall not exceed the
- limits recommended for the appropriate circumstances.

(The Commission no longer uses the term 'maximum permissible dose').

In addition to these criteria each CSIRO radiation worker shall:–

- use all personal monitoring devices issued to them through the licensee and return them at the end of the prescribed period;
- inform the Radiation Safety Officer (RSO) in advance of any new work or altered procedure involving radioactive materials or irradiating apparatus, and provide a description of agreed methods, safety precautions and emergency procedures to be used;
- report immediately to the RSO any instance of known or suspected unsafe practice or other hazardous situation.
- ensure that the chemical and physical properties and biological effects of the radiations or radioactive materials being used are personally understood;
- reduce to a minimum the radiation hazard of the work;
- have a knowledge of appropriate accident and emergency procedures;
- understand statutory regulations, codes of practice and local instructions relevant to the work they undertake.

SECTION 3 - APPOINTMENT OF RADIATION SAFETY OFFICERS AND RADIATION SAFETY COMMITTEES

Radiation Safety Officer

A Radiation Safety Officer (RSO) shall be appointed by the licensee – for each CSIRO site at which radioactive substances or irradiating apparatus are used.

The duties of the RSO based on Australian Standard AS 2243.4 are to include:–

- supervision of radiation protection to minimize personal doses;
- advising on safe working practices in accordance with statutory regulations and codes of practice;
- consulting and liaising with the relevant Statutory Authority;
- ensuring that registration and licences are current;
- monitoring and surveying areas, equipment and operations as deemed necessary and upon request;
- providing suitable personal and other monitoring devices and keeping these maintained and calibrated in accordance with Section 12 of this Code;
- arranging for records of individual worker dose equivalents to be stored by the Organisation for 50 years;
- inspecting areas and installations where ionizing radiation is used or proposed to be used and making reports and recommendations on radiation safety;
- recording and reporting unsafe practices or incidents to the Chief, licensee and State or Territory authorities where appropriate;
- preparing local rules for the handling of foreseeable accidents and emergencies;
- assembling an emergency kit and controlling radiation emergency situations.
- maintaining records of all stocks and locations of radioactive materials and irradiating apparatus and arrange for the Organisation to keep records 6 years after the date of disposal.

- arranging for the safe storage of radioactive materials and for the safe disposal of any radioactive waste;

- providing advice, instruction and local rules on radiation safety for employees working with ionizing radiation; and

- performing any other tasks that may be necessary to maintain a high standard of radiation safety in the laboratory.

Other duties prescribed under specific State or Territory legislation are also to be carried out and advice is to be provided during the OHS assessment of new projects (see Section 7).

The RSO should undergo training to ensure a high degree of knowledge of radiation safety techniques (see section 6). The RSO need not be a member of the group(s) using radioactive substances.

The RSO should be a member of, or adviser to, the local Occupational Health and Safety Committee. RSO's may be eligible for the additional remuneration payable to safety officers (Policy Circular 87/8).

The RSO should have clearly delegated authority from the licensee and the Chief on all matters related to radiation safety and should report to the licensee or Chief any departures from acceptable practice.

Radiation Safety Committee

It may be appropriate for larger sites or divisions which use radiation regularly or in situations with significant potential risk, to set up a Radiation Safety Committee or a sub-committee of the local Occupational Health and Safety Committee. Membership should be drawn from the main user groups and include the RSO, relevant staff association representation and a staff member who does not normally use radioactive substances or irradiating apparatus. The committee should function and report in a manner similar to general OHS committees.

SECTION 4 - NEW AND UPGRADED FACILITIES

CSIRO laboratories in which radioactive materials or irradiating apparatus are used can be divided into three classifications:

General Laboratories;
Radiation Laboratories; and
Radioisotope Laboratories.

When sources of ionizing radiation are used in a laboratory two basic concepts apply:

- only staff who are aware of and can protect themselves against a hazard from ionizing radiation should be permitted to enter the area; special provision should be made to protect visitors.

- should any accidental spill or release of radioactive material occur, decontamination of surfaces and equipment should proceed with the least possible personal exposure.

General Laboratories

Work involving small amounts of radioactive material may be performed in a general laboratory provided the total activity does not exceed that permitted for a laboratory graded for "low level" work in Appendix B. In determining the maximum permitted amounts, both the radiotoxicity and procedure factors are to be taken into account.

Radiation Laboratories

Radiation laboratories are those in which irradiating apparatus or sealed radioactive sources are used or stored. These laboratories must comply with Australian Standard 2243.4. Safety in Laboratories Part 4 – Ionizing Radiation and with AS 2982 Laboratory Construction. Where sources of ionizing radiation are used in large work areas (eg pilot plant buildings) the area must display the appropriate radiation warning symbols.

Requirements for Radiation Laboratories include:-

- special enclosures to house sources of ionizing radiation to protect persons outside the enclosure from primary beams or scattered radiations;
- access to a suitable radiation monitor or detector;
- visible or audible sign;
- a means of access control to restrict unauthorised entry; and
- shielding to protect staff working in adjacent work places including areas above and below the radiation laboratory.

Radioisotope Laboratories

Laboratories in which unsealed sources are used are to be graded according to the radiotoxicity of the nuclides involved, the total activity and the procedures to be adopted. To determine the grading of laboratories refer to AS2243.4 and Appendix B of this Code.

The general requirements for radioisotope laboratories include:-

- display of appropriate radiation warning signs;
- provision of internal surfaces which can be kept in a clean condition;
- clear labelling of service pipes and ventilation ducts which may become internally contaminated;
- storage space for cleaning equipment;
- adequate means for disposal for radioactive wastes;
- suitable fume cupboards for the type of work being performed;
- a delineation of "active" and "non active" areas;
- change rooms of sufficient size to segregate potentially contaminated clothing from normal work clothing;

- washing facilities with elbow or foot–operated fittings to facilitate decontamination and general washing;

- monitoring equipment as recommended for radioisotope laboratories which have been graded as "medium" or "high" in AS2243.4.

In developing plans for new or refurbished radioisotope or radiation laboratories a detailed assessment of the type of work to be performed must be made. Allowance should be made for likely increases in total activity, radiotoxicity of nuclides involved, staffing and the scope of operations.

CSIRO staff who will work in the area and relevant Statutory Authorities should be consulted before plans have been finalised for any laboratory in which ionizing radiation will be used.

SECTION 5 - PURCHASING PROCEDURES

All orders for radioactive sources or irradiating apparatus shall be checked by the RSO to ensure that:-

- a licence is held to cover the type of apparatus or specific isotope and quantity;
- activity levels and quantities ordered are the minimum reasonably necessary to effectively carry out the work. Cost savings for bulk purchase should not overide safety considerations;
- apparatus specifications fully meet the safety requirements of the licensing authority and that the manufacturer/supplier guarantees this in writing;
- labelling, packaging and transport requirements have all been specified;
- appropriate personal and area monitoring arrangements will be in place before the equipment or source is put into service; and
- staff are adequately trained to safely use the proposed apparatus or materials.

SECTION 6 - TRAINING OF RADIATION USERS AND RADIATION SAFETY OFFICERS

Training and instruction are a necessary prerequisite for all staff working with radiation or radioactive materials. These should include details on:-

- health hazards of the work;
- safe working practices and techniques;
- necessary precautions and their reasons; and
- emergency procedures.

Rules or safe working procedures dealing with radiation hazards potentially present in a laboratory shall be formulated by the laboratory supervisor in consultation with the RSO. Copies of these rules will be issued to all users who will certify that they have read and understood them.

Radiation Safety Officer

If necessary the RSO should attend a suitable training course on radiation protection, radioisotope handling and/or radioisotope techniques.

Users

All users should seek suitable training in formal courses on radiation protection and safe handling techniques.

Sources of Training

A list of suitable courses is included at Appendix C.

SECTION 7 - SAFETY ASSESSMENT OF RESEARCH PROJECTS

The Organisation's policy on the Health and Safety Assessment of Research Projects and Equipment includes a supplement on how to identify safety hazards associated with ionizing radiation work.

The RSO should assist project leaders in the preparation of safe working procedures for both routine operations and planned or special exposures. The supervising officer responsible for any project involving ionizing radiation must have completed the safety assessment procedure and have obtained approval from the RSO and the Chief/OIC before commencing practical work with radiation.

SECTION 8 – PROCEDURES FOR USE OF NEUTRON MOISTURE METERS AND RADIOACTIVE MICROSPHERES

Neutron Moisture Meters

A Neutron Moisture Meter (NMM) measures the volumetric water content of the soil. Measurements are made by lowering a probe into pre–drilled holes in the ground. The probe consists of a radioactive source (usually Americium – 241) and a detector.

All staff using a NMM should be fully aware of the various safety issues involved in the use of the device and if necessary attend an appropriate radiation safety course.

Handling Procedures

When using a NMM the radiation dose to personnel can be minimised by:–

- increasing the distance between the body and the source;
- use of shielding around the source; and/or
- operating with the shortest possible exposure time.

In practice maximising distance is the most significant means of reducing dose. Rather than carry the shielded NMM by hand, it is better to move the device around in a buggy, e.g. golf cart, from hole to hole if the nature of the experiment allows this.

During transit in a vehicle the shielded source should always be packed and secured as far away from the driver and passengers as possible. If a water container is carried it should be placed so as to shield the occupants of the vehicle.

Maintenance

Maintenance of a NMM can be especially hazardous and should only be performed by trained operators. Only emergency maintenance work should be carried out on NMMs in the field. If it is necessary to expose the source itself, through some malfunction or jamming of the probe, work rapidly and keep as far away as practical by using long–handled tools. Operators should always wear personal neutron monitors supplied in plastic press–seal envelopes, pinned to the clothing at about waist level. If possible seek advice from the RSO before commencing any maintenance operation on the device.

A useful type of shield for a probe that has been removed from the instrument is a large drum of water of radius 30cm. If the probe is placed in the centre, this will reduce the neutron dose rate to about 5% of the unshielded source value.

Radioactive Microspheres

These are small (15–20 micron diameter) plastic spheres with various radionuclides bound to them. They are chiefly used in animal studies to determine the distribution of blood flow.

The microspheres are very small and if not handled carefully may become airborne. Handling is greatly simplified if the microspheres are suspended in a liquid. If this liquid is spilt it should be promptly cleaned up before it dries and forms a powder. The area of the spill should be thoroughly monitored to identify residual activity.

SECTION 9 - TRANSPORT AND STORAGE OF RADIOACTIVE MATERIALS

The transport of radioactive materials is controlled by State, Commonwealth and International regulations. The containment, packaging and labelling of radioactive materials in transit depend upon the points of despatch, destination and upon the mode of transport. The RSO's advice and approval should be sought for details of the requirements for particular shipments.

The RSO shall ensure that:

- any radioactive material (other than exempt material) which is being transported from the site is packaged, labelled and transported in accordance with local regulations.

- where the material is in liquid form it is to be enclosed in a separate inner container that is enclosed within an outer package and is surrounded with sufficient absorbent material to ensure that if the inner container is broken in the course of transport, the material will be completely absorbed. The level of radiation at any point on the external surface of the package shall not exceed 2 micro Sv/h.

During transport, or when stored in a place for the purpose of transport, staff responsible for the package shall ensure that it is kept in a place that is separate from living accommodation, regularly occupied working places and places to which passengers or members of the public have access.

Storage in the Workplace

At the time of approving an order for a radioactive isotope, the RSO will determine the manner in which it is to be stored.

- Radioactive materials must be stored so that they present no significant hazard to persons in the vicinity and are secure against theft or unauthorized tampering.

- Materials not in continuous use should be kept in locked fireproof storage.

- Radiation levels outside the store should not normally exceed 2.5 micro Sv/h. Not all materials need to be put into storage every night. Storage of alpha emitters could be more hazardous than leaving them in the glove box where they are normally manipulated.

- Where radioactive materials are likely to evolve a radioactive gas or vapour, the store shall have separate mechanical ventilation exhausted to the outside air. The fan shall operate for at least 2 min (or one airchange) before any person enters or opens the store.

- Unsealed radioactive materials should be stored with at least 2 levels of containment.

- Unsealed radioactive residues at tracer level may be stored in glass vessels with polyethylene, rubber or cork stoppers. Glass or screw–on stoppers should not be used.

- Ionizing radiation may induce decomposition of water, hence vented containers may be needed to store aqueous radioactive solutions. (Chemically stable solutions containing about 200 MBq of alpha activity normally produce about 1 mL of gas per month, at NTP.) Bottles of old radioactive liquids should be opened only in a fume cupboard.

- Thermally unstable radioactive solutions, (eg. nitric acid or other oxidizing solutions containing traces of organic material, peroxides or chlorates) need particular care and should always be stored in a vented container. Acidic or alkaline waste should be neutralized.

- Containers used to transfer radioactive materials to and from the store should be designed to reduce the dose equivalent rate at 1 m from the surface to not more than 100 micro Sv/h, and should be constructed to prevent accidental release of the material if they are dropped or tipped over.

- Containers of radioactive material must be clearly identified and the label should indicate the nuclide, total activity, compound, specific activity, date and the level of radiation at the surface of the container and the name of the person responsible for the material.

- Specific advice concerning the safe storage of radioactive isotopes may be obtained from the RSO. All medium to high level radioactivity (as defined in Appendix B) must be stored in a radioisotope laboratory and not in a general laboratory.

SECTION 10 - STORAGE AND DISPOSAL OF RADIOACTIVE WASTE

Radioactive wastes shall be disposed of in accordance with Statutory Regulations and after consultation with the RSO.

The management of radioactive wastes must be aimed at limiting the exposure of persons to a level of radiation as low as reasonably achievable (ALARA principle). Thus, radionuclides may only be released from the laboratory at a rate which ensures that the dose equivalent limits for the public are not exceeded. Releases from adjacent laboratories must be taken into account.

The following instructions deal principally with trace level quantities of unsealed radioactive materials which present such a low hazard to the human body that disposal by the user is considered safe. [Where quantities exceed this level disposal must be approved by the RSO and appropriate Statutory Authority.]

The volume of radioactive waste should be kept to a minimum and categorised according to the method of disposal. Both solid and liquid radioactive waste shall be segregated from non–active wastes.

Solid Waste

Foot–operated waste bins with removable bucket or bag should be used for solid active material. These wastes should be segregated as advised by the RSO and in accordance with the NH&MRC Code of Practice for the Disposal of Radioactive Waste by the User.

Solid radioactive waste (tissues, pipettes, etc.) may be stored temporarily in a suitably shielded container in the laboratory until the experiment is finished, and then removed to an appropriate storage area to decay. Low activity waste may be placed in plastic lined "garbags" which should be correctly labelled with the name of the user(s), date, isotope and activity, and clearly marked with the international radiation hazard symbol. Combustible and non–combustible materials must be placed in separate containers.

Animal carcasses containing short–lived radioactivity are to be stored in a freezer in bags properly shielded and labelled. After the appropriate decay time, the waste is to be incinerated or buried under the supervision of the RSO in accordance with requirements of the Statutory Authority.

Waste containing short–lived radionuclides should be properly labelled and safely stored to allow decay before disposal. Alternatively, the waste may be diluted to an activity not exceeding that permitted to be discharged to the sewerage system and disposed of immediately if in a suitable form.

A radiation warning sign must be displayed on or close to any place where radioactive waste is stored.

Liquid Waste

All radioactive liquid waste should either be retained for the appropriate decay period in the radioisotope laboratory or a holding tank or diluted in line with requirements of the local waste authority.

Short lived radionuclides (for example ^{32}P) may be stored with suitable shielding and left to decay in the radioisotope laboratory (After 4 half–lives < 10% of the original activity remains, after 7 half–lives < 1% remains and after 10 half–lives < 0.1% remains).

High level liquid radioactive waste must be left to decay in suitably shielded and labelled containers in the radioisotope laboratory until it reaches levels permitted by the local statutory authority for discharge.

Low level liquid waste that is miscible with water should be diluted to a level acceptable to the local Statutory Authority prior to discharge into the drains via labelled sinks connected directly to the sewerage system.

Where delay tanks are used to store liquid effluent before discharge into the drains, the contents must be mixed, diluted and sampled to ensure Regulations are met.

Organic liquids must be collected and stored in separately labelled glass containers.

Scintillation vials containing ^{3}H, ^{14}C, ^{32}P, or ^{35}S must be placed in drums or bags and put into the radioisotope laboratory, properly shielded and labelled. Vials must not be allowed to accumulate in the laboratory as they are both a fire and a health hazard.

Liquid scintillation waste may be incinerated if permitted by the relevant Statutory Authority. If plastic vials are used they must be promptly disposed of to avoid solvent loss and consequent fire and/or inhalation problems. Glass vials with metal caps should not be used because of the danger of explosion during incineration. Glass vials with plastic caps, in limited numbers, may be disposed of by incineration.

Airborne Waste

Radioactive aerosols or gases shall be diluted, filtered or treated at the point of discharge to ensure the quantity does not exceed levels permitted by the relevant Statutory Authority.

All exhaust from a radioisotope laboratory or a fume cupboard used to handle radioactive material shall be discharged through a suitable stack into the open air in such a way as to prevent it being directly drawn into any air intake or occupied area.

Return to Suppliers

Where sealed or unsealed radioactive sources or materials are no longer required by the user, suppliers of these materials may accept the return of these and/or the waste arising from their usage. Where permission for return has been granted by the supplier, they shall be stored, packaged and transported in accordance with the recommendations set out in Section 9.

Records

Records covering the disposal of radionuclides must comply with the requirements of the Statutory Authority. The record should specify the radionuclide, estimated activity, physical nature, the date and form of disposal and other information required by the Authority.

SECTION 11 - MONITORING AND MEDICAL SURVEILLANCE

Area Monitoring

Each laboratory in which irradiating apparatus or radioactive material is used shall have direct access to monitoring equipment appropriate for the source concerned. RSOs shall ensure that spare monitoring equipment is available for use during breakdown, servicing or calibration periods.

Personal Monitoring

Licensees and RSO's have a legal responsibility to implement a personal monitoring program and all staff using radiation sources (ie, radioactive sources or irradiating equipment) shall comply with all requirements. Supervisors should not allow access to equipment or sources by any staff or visiting scientists who are not prepared to comply fully with monitoring requirements.

Staff, at all times, when at work in radiation areas, must wear in an approved manner, an appropriate dosimeter as recommended by the RSO. Additional dosimeters shall be kept for personnel not on the program who need to enter the area (eg maintenance or visitors) and shall be issued to those persons on an individual basis, ie not reissued without the dose for that individual having been determined.

Finger dosimeters must be worn by staff working with X–ray diffraction and X–ray fluorescence apparatus, particularly when engaged in sample manipulation or beam alignment (ie single crystal orientation). Such manipulations or alignments should ideally be carried out with the beam off, but where that is not practicable, the staff member carrying out the alignment should ensure that no other staff or visitors are in the vicinity of the beam.

If dosimeters are required for experimental measurement, or to estimate dose to the extremities of the body, a special issue of dosimeters should be arranged with the dosimeter service.

Results obtained from the service are to be recorded and retained as outlined in Section 13. The RSO will examine each set of results and where personal doses, either short term or cumulative, exceed those specified by the licensing authority, the RSO will advise the staff member, the licensee and Chief.

Photographic badge and finger monitor services are available from ANSTO Lucas Heights, The Australian Radiation Laboratory (Commonwealth) in Melbourne and from some State Health Department Laboratories. Factors such as cost, reliability and turn-around time should be taken into account in selecting an appropriate service.

Biological Monitoring

Biological monitoring programs are designed to assess the significance of any radioactive substances taken into the bodies of individuals who are exposed to such materials in the course of their work.

There are various methods available to assess body or organ radionuclide content. They include:-

- whole body monitoring for radioactive materials;
- organ monitoring (eg thyroid counting) for radioactive materials;
- measurement of levels of radioactive materials present in body excreta;
- analysis of hair sample (eg for uranium); and
- breath analyses (eg for radon).

The requirements of any routine bioassay program or 'special' bioassay monitoring will be determined by the RSO in consultation with the CSIRO Occupational Health and Safety Section.

Medical Surveillance

Any personal dose levels above statutory limits must be discussed with the CSIRO Occupational Health and Safety Section which will advise on the need for medical examinations or treatment.

SECTION NO. 12 - CALIBRATION OF MONITORING EQUIPMENT

It is the responsibility of the RSO to ensure that all instruments used for the detection and measurement of ionizing radiation are maintained in good working condition and properly used.

When instruments are first taken into use, the RSO shall ensure that they have been tested and calibrated. Thereafter the RSO should ensure that provision is made for all instruments to be tested annually or after the repair of any defect that could affect their accuracy. The dates and results of all tests and calibrations shall be recorded and the records kept for six years after the last entry.

Methods of Testing

There are two types of tests usually carried out on a radiation measurement instrument:-

- a full calibration to confirm that the reading is within its stated accuracy;
- a check that accuracy has not changed significantly after a particular period of use.

The first of these tests should be carried out at a laboratory equipped with calibration facilities.

The second can usually be carried out by the RSO at a site using a radioactive source.

Calibrations can be arranged through the Radiation Branch of the relevant State or Territory Department of Health, the Australian Radiation Laboratory (Lower Plenty Road, Yallambie, Victoria, 3085) or the Australian Nuclear Science and Technology Organisation at Lucas Heights.

SECTION 13 – RECORDS TO BE KEPT

The keeping of records is a statutory requirement under the various licensing arrangements for the use of radioactive materials or irradiating apparatus.

The records to be kept are:–

- Licences
- Register of radioactive sources
- Register of irradiating apparatus
- Record of doses received by personnel
- Laboratory survey and instrument calibration reports.

Register of Radioactive Sources

A Register of radioactive sources shall be kept to account for all radioactive materials which enter, leave, or remain on the site.

As radioactive material is used in two general forms (sealed or unsealed sources), it is necessary that the register be designed so that the various characteristics of these sources can be noted.

The information to be recorded for sealed or unsealed sources shall include:–

- Radionuclide
- Chemical Form
- Sealed/Unsealed
- Activity at stated dates
- Serial Number if applicable
- Delivery Date
- Storage/use location
- Disposal Date
- Method of Disposal

Register of Irradiating Apparatus

The following details are to be kept:–

Details of Irradiating Apparatus

- Manufacturer
- Model/Model No.
- Operating Factors: Maximum kV
  Maximum mA

List of staff authorised to use the apparatus

- Responsible Officer/s
- Other users

Personal Dosimetry Records

Radiation dose records for each staff member shall be kept and made available for inspection by the staff member required to use a dosimeter involved as well as authorised officers of the licensing authority and CSIRO health and safety staff.

The personal dosimetry record for each member of staff shall be kept and, where the dose exceeds prescribed limits, details shall be entered in a central register at the site and shall include the following:–

- Name
- Date of issue and return of dosimeter
- Type of dosimeter
- Dose recorded; and
- Dose equivalent recorded for year.

In addition, there may be other statutory reporting requirements which must be fulfilled.

Records of Area Surveys

The purpose of workplace radiation monitoring is to identify areas where significant dose rates may exist or where persons may be contaminated both internally or externally through the spread of sealed radioactive materials.

The frequency and method of monitoring particular work areas is dependent on the type of work being performed and is at the discretion of the RSO. As a general rule work surfaces should be surveyed both before and after any work involving unsealed radioactive materials. Surveys of work areas where sealed sources or irradiating apparatus are used should be undertaken at the discretion of the RSO, usually when the source or apparatus has been altered in some way, although periodic surveys are also necessary (at least annually). Sealed sources should be leak tested annually.

Survey records from monitoring of levels of external radiation, surface contamination and airborne contamination must be retained in a register kept by the RSO. These should include:–

- Date
- Areas Surveyed
- Purpose of survey (eg surface contamination);
- Instrument used
- Results.

Calibration Records

Radiation monitoring equipment is to be calibrated (see Section 12) and the following information recorded.

- Instrument name/number
- Serial number
- Calibration factor to be applied (if it exceeds + 20%)
- Date calibrated
- Date next calibration required
- Calibrating officer/organisation

This information should also be displayed on the instrument.

Retention of Records

All records of personal doses are to be retained by the Organisation for a period of 50 years. Records of surveys or information on sources is to be kept for a period of six years after the date of disposal of the source concerned.

SECTION 14– REPORTING INCIDENTS AND DEALING WITH EMERGENCIES

Incidents involving radioactive sources can be broadly defined under the following categories:–

- releases of radioactive contaminants;
- excessive exposure of personnel to radiation;
- theft or loss of radioactive materials; and
- deliberate misuse of radioactive materials.

Reporting

Releases of Radioactive Materials

Where the release of radioactive material is of a minor nature, e.g. in a spill of a working solution, the incident should be reported immediately to the RSO. The RSO will determine if further reporting is necessary and supervise the emergency procedures, such as decontamination and cleanup. Further reporting should be considered necessary where there is any contamination of personnel or the incident necessitates any expenditure for rectification or is required by any statutory code or regulations.

Major releases of radioactivity will be unlikely given the nature of the radioactive material in use at the majority of CSIRO Divisions. However, incidents such as the rupturing of a transport container or the breakage of a container of high specific activity isotope may be considered as major releases. In cases such as these, the local OHS Committee (through the RSO), the relevant Statutory Authority and the OHSU must be notified. Standard CSIRO incident reporting procedures (PC 87/12) are to be used.

Exposure of Personnel

Exposure of personnel by either contamination or irradiation should be reported to the RSO immediately and then to the licensee and Chief/OIC and, where required, to the appropriate Statutory Authority. Advice should be sought from the CSIRO Occupational Health and Safety Section.

Theft or Loss

Theft or loss of radioactive materials is a serious matter which could bring adverse publicity to the Organisation and cause alarm in the community.

As soon as it is confirmed that the radioactive material is missing, the Federal Police and the relevant Statutory Authority must be notified and the Chief, appropriate Director and the OHS Section advised.

A committee should be established by the Chief to investigate the matter.

The Chief or OIC should liaise with the Director and licensing authority regarding media releases.

Deliberate Misuse

Deliberate misuse of equipment or sources constitutes a serious breach of statutory and common law requirements and endangers the safety of persons other than those responsible for the misuse. Where such a breach occurs Chiefs and supervisors shall make use of available options depending on the situation:–

- withdrawal of permission to use radiation sources; and/or
- application of provisions of the CSIRO Disciplinary Code

Investigation of Incidents

All radiation incidents including near misses, shall be investigated. The requirements of CSIRO Policy Circular 87/12 will suffice unless the licensing authority has specific requirements in which case these must also be met.

Decontamination of Persons

Persons suspected of having received any appreciable intake of radioactive material shall be removed from the area of contamination. The accident must be reported immediately to the RSO and Statutory Authority from whom further advice shall be sought.

When serious spills occur, expert assistance should be summoned immediately. While waiting for this assistance to arrive any obvious injury should be treated immediately, taking care to avoid undue spread of contamination.

Contaminated clothing should be removed and personal decontamination started as follows according to the area of the body where contamination has occurred:

(a) Eyes should be irrigated with saline solution (1 percent common salt solution) or distilled or tap water. A standard plastics wash bottle is a convenient applicator if used with care.

(b) Hands should be washed with soap and water, scrubbing lightly with a soft nail–brush. If this fails to remove the contamination, repeat with a detergent. For contamination which is difficult to remove, wearing tight–fitting rubber gloves for several hours, to promote perspiring of the hands, often assists removal of the contamination. As a last resort, immerse the hands in saturated potassium permanganate solution, allow to dry and remove stain with 5 percent sodium metabisulphite solution.

(c) Skin, other than that on hands, should be rubbed gently with a cotton wool pad soaked in a complexing agent (eg. Cetavlon). Do not scrub the skin sufficiently to produce abrasions.

(d) The mouth should be washed out several times with hydrogen peroxide solution (one tablespoon of 10 volume solution to a tumbler of water).

(e) Contaminated wounds should be washed under a fast running tap and bleeding encouraged; if on the face, take care not to contaminate the eyes, mouth or nostrils. Finally wash the wound with water, apply a gentle antiseptic and then a first–aid dressing.

Personal decontaminaton should be continued until monitoring shows that contamination has been reduced to an acceptable level, unless there is a risk of contamination entering the bloodstream through roughening or breaking of the skin.

Persons suspected of having received any appreciable accidental external radiation dose should be removed from the area containing the source of the radiation. The accident must be reported immediately to the RSO and Statutory Authority from whom further advice shall be sought.

Appropriate control measures shall be instituted to remove the source of external irradiation and return conditions to normal.

All possible attempts should be made immediately to estimate the radiation dose received, to provide guidance on the need for subsequent medical attention.

Cleaning Up After A Spill

Techniques for removal of contamination involve consideration of the value of the contaminated items and the durability of the surfaces which are contaminated. A summary of techniques which have been successfully employed in decontamination of various materials is given below. Values of maximum acceptable contamination for items to be taken outside radiological laboratories are given in AS2243.4.

Tools and Glassware

Decontamination methods fall into two broad classifications: corrosive and non–corrosive. Whilst it is desirable to use a non–corrosive method, this is seldom practical because removal of the surface layers of material is more effective in putting ions back into solution than the very slow processes of ion exchange or desorption by non–corrosive methods.

Some of the more common decontamination procedures involving both corrosive and non–corrosive methods are:–

1. All glassware should be washed with acid (chromic acid cleaning solution or concentrated nitric acid) and rinsed as a routine procedure following use (rinse thoroughly but avoid splashing). All metal tools employed should be surveyed to detect possible contamination.

2. The use of acid on metal tools may cause unnecessary corrosion and present greater difficulty in future decontamination procedures. Some elements (e.g. iodine) will become volatile upon reaction with acids; in such cases it may be desirable to first attempt decontamination with detergents. The use of customised detergent (eg Decon) and specialised cleaning methods such as ultra–sonic cleaning baths may be appropriate.

Equipment that is found to be contaminated after the initial treatment should be stored in an isolated location, possibly in a hood with adequate exhaust or under water, until more thorough decontamination procedures may be applied. If it is necessary to dismantle equipment prior to decontamination procedures, a careful survey should be made during the operation. Contaminated equipment should not be released from control of the laboratory for repair or any other purpose until the level of activity has been reduced to a safe limit. Where the half–life of the contaminating element is short, it may be desirable to store tools and glassware for decay of activity rather than to attempt decontamination. In many cases, if the items are cheap or easily replaced, it may be simpler to dispose of such equipment in a recommended manner and replace with new apparatus.

Equipment that is contaminated with long–lived isotopes and that cannot be satisfactorily decontaminated, must be regarded as radioactive waste and disposed of or stored accordingly.

Glass and porcelain articles may be cleaned with mineral acids, ammonium citrate, trisodium phosphate, cleaning solution (chromic acid) or ammonium bifluoride. When the glaze is broken on porcelain, or when active solutions are heated to extreme dryness in glass, decontamination is very difficult and usually it is more convenient to replace items so treated.

Metal objects may be decontaminated with dilute mineral acids (nitric), a 10 percent solution of sodium citrate, or ammonium bifluoride. Use hydrochloric acid when all other procedures for stainless steel fail. Hydrochloric acid is a good decontaminant because it removes some of the surface, although this procedure results in etching of the stainless

steel, which makes it less desirable for future use. It has been demonstrated that brass polish is an excellent decontaminant for brass. Plastics may be cleaned with ammonium citrate, dilute acids or organic solvents.

For practical purposes, two applications of a decontamination process are considered appropriate for optimum effectiveness.

Laboratory Equipment

Laboratory equipment should be surveyed for residual contamination following decontamination procedures. Decontamination seldom exceeds 99.9 per cent efficiency and usually is considerably less efficient. If the residual contamination indicates that the level of activity is still greater than permissible, equipment of this nature should be broken up to prevent accidental return to stock or other use.

Glassblowing, welding, brazing, soldering, etc., should never be permitted on equipment contaminated with radioactive materials unless it is done in specially ventilated facilities, and unless special techniques are used to prevent the inhalation of radioactive dust and fumes.

Floor and Benches

Clean carefully as described below using caution not to spread contamination. If material is dry use masking or adhesive tape to remove loose contaminants; if material is wet use absorbent material such as towels, "kim wipes", disposable diapers, or toilet tissue. If a wet mop will not remove the contamination, proceed with a method suitable for the particular surface material.

Surface	Method of Decontamination
Linoleum	kerosene, ammonium citrate solution or diluted mineral acids(care should be taken not todissolve sealing compounds at the edges and between cracks of the linoleum).
Ceramic tile	mineral acids, ammonium citrate or tri–sodiumphosphate.
Paint	10% hydrochloric acid is sometimes successful.
Concrete surface	concrete must be removed with a chisel.
Wood surfaces	must be planed.

Plumbing

The following procedures may be used to decontaminate sinks, taps and drains:–

1. Flush thoroughly with a large volume of water.

2. Scour with a rust remover and flush thoroughly.

3. Soak in a solution of citric acid prepared by adding 0.5kg of acid to 4.5 litres of water and flush thoroughly.

SECTION 15 - CODES OF PRACTICE, STANDARDS AND LEGISLATION

Much of the information contained in the following codes and standards is included in State and Territory regulations. They may also be used as a guide to good practice.

Licence holders and RSOs are advised to obtain the relevant documents and ensure that relevant design, operational and monitoring aspects are included in local procedures. Compliance with codes and standards, particularly those of SAA and the NH&MRC is an essential first step in providing legal proof of compliance with common law obligations.

Existing Codes and Standards

Australian Standard 2243.4 Safety in Laboratories, Part 4. Ionizing Radiation. Standards Association of Australia.

Recommended Radiation Protection Standards for Individuals Exposed to Ionising Radiation. National Health and Medical Research Council, AGPS.

Code of Practice for the Safe Transport of Radiation Substances, Department of Home Affairs and Environment, AGPS Canberra (1982).

Code of Practice for the Disposal of Radiation Wastes by the User (1985). National Health and Medical Research Council, AGPS.

Code of Practice for Protection Against Ionizing Radiation Emitted from X-ray Analysis Equipment (1984). National Health and Medical Research Council, AGPS.

Code of Practice for the Safe Use of Soil Density and Moisture Gauges Containing Radioactive Sources (1984). National Health and Medical Research Council, AGPS.

Notes on medical procedure for radiation accidents and radioactive contamination. May 1968. National Health and Medical Research Council, AGPS.

Code of Practice for the safe use of ionizing radiation in veterinary radiology: Parts 1 and 2, June 1982. National Health and Medical Research Council, AGPS.

Code of Practice for safe use of ionizing radiation in veterinary radiology: Part 3 – Radiotherapy (1984), National Health and Medical Research Council, AGPS.

Code of Practice for the Control and Safe Handling of Sealed Radioactive Sources Used in Industrial Radiography, May – 1968. National Health and Medical Research Council, AGPS.

What the General Practitioner Should Know About Medical Handling of Overexposed Individuals. International Atomic Energy Agency publication TEC DOC–366.

SECTION 16 - BIBLIOGRAPHY

An Introduction to Radiation Protection. A Martin and S.A.Harbison; Chapman and Hall; 3rd Ed. 1986

Introduction to Health Physics. H.Cember; Pergamon Press; 2nd Ed. 1983

APPENDIX A

STATUTORY AUTHORITIES

Australian Capital Territory

Consultant, Radiation Safety
ACT Radiation Council
Capital Territory Health Commission
GPO Box 825
CANBERRA CITY ACT 2601
Telephone: (062) 47.2899

New South Wales

Officer–in–Charge
Radiation Health Services
Department of Health
PO Box 163
LIDCOMBE NSW 2141
Telephone: (02) 646.0222

Northern Territory

Director
Occupational & Environmental Health
NT Department of Health
GPO Box 1701
DARWIN NT 5794
Telephone: (089) 80.2911

Tasmania

Health Physicist
Division of Public Health
Department of Health Services
PO Box 191B
HOBART TAS 7001
Telephone: (002) 30.6421

Queensland

Director
Division of Health & Medical Physics
Department of Health
535 Wickham Terrace
BRISBANE QLD 4000
Telephone: (07) 224.5611

Victoria

Senior Scientific Officer
Radiation Safety Section
Health Commission of Victoria
555 Collins Street
MELBOURNE VIC 3000
Telephone: (03) 616.7777

South Australia

Senior Health Physicist
Occupational Health & Radiation
Control Branch
South Australian Health Commission
GPO BOX 1313
ADELAIDE SA 5001
Telephone: (08) 218.3211

Western Australia

The Secretary
Radiological Council
Radiation Health Branch
Health Department of
Western Australia
Verdun Street
NEDLANDS WA 6009
Telephone: (09) 380.1122

APPENDIX B

LABORATORY GRADING

The grading system adopted by CSIRO to distinguish between that which can be safely handled in a general laboratory and that which requires radiation or radioisotope laboratory is based on two major factors:–

(i) the radiotoxicity of the nuclide used; and

(ii) the procedure being employed (e.g. procedures where respirable radioactive dusts are generated are normally more hazardous than simple wet chemistry procedures and should be weighted accordingly)

TABLE B1 classifies principal radioactive nuclides into four classes (very high, high, moderate and low radiotoxicity). Radiotoxicity is a measure of the ability of a radionuclide when taken into the body, to cause damage to tissues or organs.

TABLE B1

CLASSIFICATION OF RADIOTOXICITIES

The principal radioactive nuclides are classified as follows, according to their relative radiotoxicity:-

(a) Very high radiotoxicity (Class 1):

$^{210}_{82}Pb$	$^{210}_{84}Po$	$^{223}_{88}Ra$	$^{225}_{88}Ra$	$^{226}_{88}Ra$	$^{228}_{88}Ra$	$^{227}_{89}Ac$	$^{227}_{90}Th$
$^{228}_{90}Th$	$^{229}_{90}Th$	$^{230}_{90}Th$	$^{231}_{91}Pa$	$^{230}_{92}U$	$^{232}_{92}U$	$^{233}_{92}U$	$^{234}_{92}U$
$^{237}_{93}Np$	$^{236}_{94}Pu$	$^{238}_{94}Pu$	$^{239}_{94}Pu$	$^{240}_{94}Pu$	$^{241}_{94}Pu$	$^{242}_{94}Pu$	$^{241}_{95}Am$
$^{242}_{95}Am$	$^{243}_{95}Am$	$^{240}_{96}Cm$	$^{242}_{96}Cm$	$^{243}_{96}Cm$	$^{244}_{96}Cm$	$^{245}_{96}Cm$	$^{246}_{96}Cm$
$^{247}_{96}Cm$	$^{248}_{96}Cm$	$^{248}_{98}Cf$	$^{249}_{98}Cf$	$^{250}_{98}Cf$	$^{251}_{98}Cf$	$^{252}_{98}Cf$	$^{254}_{98}Cf$
$^{254}_{99}Es$	$^{255}_{99}Es$						

(b) High radiotoxicity (Class 2):

$^{222}_{11}Na$	$^{36}_{17}Cl$	$^{45}_{20}Ca$	$^{46}_{21}Sc$	$^{60}_{27}Co$	$^{90}_{38}Sr$	$^{91}_{39}Y$	$^{93}_{40}Zr$
$^{94}_{41}Nb$	$^{106}_{44}Ru$	$^{110m}_{47}Cd$	$^{115m}_{48}Cd$	$^{114m}_{49}In$	$^{124}_{51}Sb$	$^{125}_{51}Sb$	$^{124}_{53}I$
$^{125}_{53}I$	$^{126}_{53}I$	$^{131}_{53}I$	$^{134}_{55}Cs$	$^{140}_{56}Ba$	$^{144}_{58}Ce$	$^{152}_{63}Eu$(13a)	
$^{154}_{63}Eu$	$^{160}_{65}Tb$	$^{170}_{69}Tm$	$^{181}_{72}Hf$	$^{183}_{73}Ta$	$^{192}_{77}Ir$	$^{204}_{81}Tl$	$^{212}_{82}Pb$
$^{207}_{83}Bi$	$^{210}_{83}Bi$	$^{211}_{85}At$	$^{224}_{88}Ra$	$^{228}_{89}Ac$	$^{232}_{90}Th$	Th nat 90	
$^{230}_{91}Pa$	$^{236}_{92}U$	$^{244}_{94}Pu$	$^{242}_{95}Am$	$^{241}_{96}Cm$	$^{249}_{97}Bk$	$^{246}_{98}Cf$	$^{253}_{98}Cf$
$^{253}_{99}Es$	$^{254m}_{99}Es$	$^{255}_{100}Fm$	$^{256}_{100}Fm$				

(c) Moderate radiotoxicity (Class 3):

$^{7}_{4}Be$	$^{14}_{6}C$	$^{18}_{9}F$	$^{24}_{11}Na$	$^{31}_{14}Si$	$^{32}_{15}P$	$^{33}_{15}P$	$^{35}_{16}S$
$^{38}_{17}Cl$	$^{41}_{18}Ar$	$^{42}_{19}K$	$^{43}_{19}K$	$^{47}_{20}Ca$	$^{47}_{21}Sc$	$^{48}_{21}Sc$	$^{48}_{23}V$
$^{51}_{24}Cr$	$^{52}_{25}Mn$	$^{54}_{25}Mn$	$^{52}_{26}Fe$	$^{55}_{26}Fe$	$^{59}_{26}Fe$	$^{55}_{27}Co$	$^{56}_{27}Co$
$^{57}_{27}Co$	$^{58}_{27}Co$	$^{63}_{28}Ni$	$^{65}_{28}Ni$	$^{64}_{29}Cu$	$^{65}_{30}Zn$	$^{69m}_{30}Zn$	$^{72}_{31}Ga$
$^{73}_{33}As$	$^{74}_{33}As$	$^{76}_{33}As$	$^{77}_{33}As$	$^{75}_{34}Se$	$^{82}_{35}Br$	$^{74}_{36}Kr$	$^{77}_{36}Kr$
$^{87}_{36}Kr$	$^{88}_{36}Kr$	$^{86}_{37}Rb$	$^{83}_{38}Sr$	$^{85}_{38}Sr$	$^{89}_{38}Sr$	$^{91}_{38}Sr$	$^{92}_{38}Sr$
$^{90}_{39}Y$	$^{92}_{39}Y$	$^{93}_{39}Y$	$^{86}_{40}Zr$	$^{88}_{40}Zr$	$^{89}_{40}Zr$	$^{95}_{40}Zr$	$^{97}_{40}Zr$
$^{90}_{41}Nb$	$^{93m}_{41}Nb$	$^{95}_{41}Nb$	$^{95m}_{41}Nb$	$^{96}_{41}Nb$	$^{90}_{42}Mo$	$^{93}_{42}Mo$	$^{99}_{42}Mo$
$^{96}_{43}Tc$	$^{97m}_{43}Tc$	$^{97}_{43}Tc$	$^{99}_{43}Tc$	$^{97}_{44}Ru$	$^{103}_{44}Ru$	$^{105}_{44}Ru$	$^{105}_{45}Rh$
$^{103}_{46}Pd$	$^{109}_{46}Pd$	$^{105}_{47}Ag$	$^{111}_{47}Ag$	$^{109}_{48}Cd$	$^{115}_{48}Cd$	$^{115m}_{59}In$	$^{113}_{50}Sn$
$^{125}_{50}Sn$	$^{122}_{51}Sb$	$^{121}_{52}Te$	$^{121m}_{52}Te$	$^{123m}_{52}Te$	$^{125m}_{52}Te$	$^{127m}_{52}Te$	$^{129m}_{52}Te$
$^{131}_{52}Te$	$^{131m}_{52}Te$	$^{132}_{52}Te$	$^{133m}_{52}Te$	$^{134}_{52}Te$	$^{120}_{53}I$	$^{123}_{53}I$	$^{130}_{53}I$
$^{132}_{53}I$	$^{132m}_{53}I$	$^{133}_{53}I$	$^{135}_{53}I$	$^{135}_{54}Xe$	$^{132}_{55}Cs$	$^{136}_{55}Cs$	$^{137}_{55}Cs$
$^{137}_{56}Ba$	$^{140}_{57}La$	$^{134}_{58}Ce$	$^{135}_{58}Ce$	$^{137m}_{58}ce$	$^{139}_{58}Ce$	$^{141}_{58}Ce$	$^{143}_{58}Ce$
$^{142}_{59}Pr$	$^{143}_{59}Pr$	$^{147}_{60}Nd$	$^{149}_{60}Nd$	$^{147}_{61}Pm$	$^{149}_{61}Pm$	$^{151}_{62}Sm$	$^{153}_{62}Sm$
$^{152m}_{63}Eu(9h)$		$^{155}_{63}Eu$	$^{153}_{64}Gd$	$^{159}_{64}Gd$	$^{165}_{66}Dy$	$^{166}_{66}Dy$	$^{166}_{67}Ho$
$^{169}_{68}Er$	$^{171}_{68}Er$	$^{171}_{69}Tm$	$^{175}_{70}Yb$	$^{177}_{71}Lu$	$^{181}_{74}W$	$^{183}_{74}W$	$^{187}_{74}W$
$^{183}_{75}Re$	$^{186}_{75}Re$	$^{188}_{75}Re$	$^{185}_{76}Os$	$^{191}_{76}Os$	$^{193}_{76}Os$	$^{190}_{77}Ir$	$^{194}_{77}Ir$

$^{191}_{78}Pt$	$^{193}_{78}Pt$	$^{197}_{78}Pt$	$^{196}_{79}Au$	$^{198}_{79}Au$	$^{199}_{79}Au$	$^{197}_{80}Hg$	$^{197m}_{80}Hg$
$^{203}_{80}Hg$	$^{200}_{82}Tl$	$^{201}_{81}Tl$	$^{202}_{81}Tl$	$^{203}_{82}Pb$	$^{206}_{83}Bi$	$^{212}_{83}Bi$	$^{220}_{86}Rn$
$^{222}_{86}Rn$	$^{226}_{90}Th$	$^{231}_{90}Th$	$^{234}_{90}Th$	$^{233}_{91}Pa$	$^{231}_{92}U$	$^{237}_{92}U$	$^{240}_{92}U$
$^{240}_{92}U$	$^{240}_{93}Np$	$^{239}_{93}Np$	$^{234}_{94}Pu$	$^{237}_{94}Pu$	$^{245}_{94}Pu$	$^{238}_{95}Am$	$^{240}_{95}Am$
$^{244}_{95}Am$	$^{244m}_{95}Am$	$^{238}_{96}Cm$	$^{250}_{97}Bk$	$^{244}_{98}Cf$	$^{254}_{100}Fm$		

(d) Low radiotoxicity (Class 4):

$^{3}_{1}H$	$^{15}_{8}O$	$^{37}_{18}Ar$	$^{51}_{25}Mn$	$^{52m}_{25}Mn$	$^{53}_{25}Mn$	$^{56}_{25}Mn$	$^{58m}_{27}Co$
$^{60m}_{27}Co$	$^{61}_{27}Co$	$^{62m}_{27}Co$	$^{59}_{28}Ni$	$^{69}_{30}Zn$	$^{71}_{32}Ge$	$^{76}_{36}Kr$	$^{79}_{36}Kr$
$^{81}_{36}Kr$	$^{83m}_{36}Kr$	$^{85m}_{36}Kr$	$^{85}_{36}Kr$	$^{80}_{38}Sr$	$^{81}_{38}Sr$	$^{85m}_{38}Sr$	$^{87m}_{38}Sr$
$^{91m}_{19}Y$	$^{88}_{41}Nb$	$^{89(66m)}_{41}Nb$		$^{89(122m)}_{41}Nb$		$^{97}_{41}Nb$	$^{98}_{41}Nb$
$^{93m}_{42}Mo$	$^{101}_{42}Mo$	$^{96m}_{43}Tc$	$^{99m}_{43}Tc$	$^{103m}_{45}Rh$	$^{113m}_{49}In$	$^{116}_{52}Te$	$^{123}_{52}Te$
$^{127}_{52}Te$	$^{129}_{52}Te$	$^{133}_{52}Te$	$^{120m}_{53}I$	$^{121}_{53}I$	$^{128}_{53}I$	$^{129}_{53}I$	$^{134}_{53}I$
$^{131m}_{54}Xe$	$^{133}_{54}Xe$	$^{125}_{55}Cs$	$^{127}_{55}Cs$	$^{129}_{55}Cs$	$^{130}_{55}Cs$	$^{131}_{55}Cs$	$^{134m}_{55}C_{\cdot}$
$^{135}_{55}Cs$	$^{135m}_{55}Cs$	$^{138}_{55}Cs$	$^{137}_{58}Ce$	$^{191m}_{76}Os$	$^{193m}_{78}Pt$	$^{197m}_{78}Pt$	$^{203}_{84}Po$
$^{203}_{84}Po$	$^{207}_{84}Po$	$^{227}_{88}Ra$	$^{235}_{92}U$	$^{218}_{92}U$	$^{219}_{92}U$	U nat 92	
$^{235}_{94}Pu$	$^{243}_{94}Pu$	$^{237}_{95}Am$	$^{239}_{95}Am$	$^{245}_{95}Am$	$^{246m}_{95}Am$	$^{246}_{95}Am$	$^{249}_{96}Cm$

Specified Levels of Activity for Grading Laboratories

This table indicates the specified levels of activity permitted in general (low level) laboratories and radioisotope laboratories.

TABLE B2

GRADING OF LABORATORIES

Grade of CSIRO laboratory required for specific levels of activity

Radiotoxicity class	General (low level) Laboratory	Radiation or Radioisotope Laboratory
Class 1	<0.4 MBq	0.4 MBq and above
Class 2	<40 MBq	40 MBq and above
Class 3	<4 GBq	4 GBq and above
Class 4	<0.4 TBq	0.4 TBq and above

NOTE: The specific activity levels in this table are derived from recommendations of the Internatonal Atomic Energy Agency.

TABLE B3

PROCEDURE FACTORS

As the degree of hazard in radioisotope work is largely determined by the nature of the work i.e the potential for radioactive contamination, the procedure factors in Table B3 may be applied to modify the grading based on the operations being performed in the laboratory.

Procedure	Factor
Simple Storage.....	X 100
Very simple wet operations (eg.preparations of aliquots of stock solutions	X 10
Normal chemical operations (eg. analysis of simple chemical preparations)	X 1
Complex wet operations (eg. multiple operations, or operations with complex glass apparatus) .	X 0.1
Simple dry operations (eg. manipulations of powders) and work with volatile radioactive compounds	X 0.01
Complex dry operations (eg. where powders are likely to become airborne) and work with radioactive gases..	X 0.001

Examples:

(a) A very simple wet chemical operation involving preparation of aliquats of ^{14}C–labelled protein (procedure factor of 10) would be required to be performed in a radioisotope laboratory when the total activity of ^{14}C = Class 3 Radiotoxicity.
That is 4GBq X 10 = 40GBq.

(b) If the project involves iodination of a sample, the work would need to be performed in a radioisotope laboratory when the activity of ^{131}I exceeded (Class 2) Radiotoxicity, ie. 40MBq X 1 = 40MBq.

NOTE: Labelled organic material of special biological importance may be metabolized differently to the elemental form, and hence may present a gresater hazard than normal. for example, 3H–labelled or 14C–labelled thymidine is not metabolized but is retained intact by the body. In such cases, an additional grading factor of 0.1 should be applied.

APPENDIX C

RADIATION SAFETY TRAINING COURSES

1. Australian School of Nuclear Technology
   Private Mail Bag
   SUTHERLAND NSW 2232

   A. Radiation Protection Course.
   Four week course.

   B. Radioisotope Course for Non–Graduates.
   Four week course.

   C. Radioisotope Course for Graduates.
   Four week course.

   D. Radiation Protection/Handling Course (planned for CSIRO (one/three day course)

2. Bruce College of Technical and Further Education
   PO Box 90
   BELCONNEN ACT 2616

   Radiochemistry Safety/Handling Technique
   3 hours per week for 18 weeks.

3. Canberra College of Technical and Further Education
   Constitution Avenue
   REID ACT 2601

   Fixed Source Radiation Safety Course – No. NC92A.

4. South Australian Institute of Technology
   North Terrace
   ADELAIDE SA 5000

   Radiation Protection for Users of Sealed and Unsealed Radioactive Sources.
   three day course.

5. University of New South Wales
   PO Box 1
   KENSINGTON NSW 2033

   Radiation Protection
   42 hour course.

6. West Australia Public Health Centre
   Radiation Health Branchvarious courses.

   various courses