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GUIDELINE FOR SAFE USE OF UNSEALED RADIOACTIVE NUCLIDES

The use of unsealed radioactive sources is subject to regulatory control in terms of the Hazardous Substances Act 15 of 1973, as amended. The body now responsible for administering this legislation is SAHPRA Radiation Control.

This code describes the requirements laid down by Radiation Control for premises such as radioisotope laboratories, counting rooms, administration rooms (for in-vivo applications) and storerooms, and describes procedures for the safe use of unsealed radioactive material.

Wherever the word must is used in this document, it implies that the requirement in question is compulsory. Where the word should is used, compliance is strongly recommended but is not mandatory.

Document History

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0	First issue and published for implementation	April 1994
1	- Content structured on the new SAHPRA Guideline Template - A unique document number SAHPGL-RDN-RN-06 allocated to this Guideline	January 2024

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Glossary

Abbreviation/ Term	Meaning
ALI_{min}	annual limits on intake (prescribed in ICRP Publication 61, *Annual Limits on intake of Radionuclides by Workers Based on the 1990 Recommendations*)
GBq	gigabecquerel, a unit of activity (10^9 becquerel)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
LAF	laminar airflow
MBq	megabecquerel, a unit of activity (10^6 becquerel)
mSv	millisievert, a unit of equivalent dose (10^{-3} sievert)
NCRP	National Council on Radiation Protection and Measurements (USA)
PVC	polyvinyl chloride
R	rem [roentgen equivalent in man], a unit a unit of equivalent dose (1 rem = 10^{-2} sievert)
RIA	radioimmunoassay
SABS	South African Bureau of Standards
TLD	thermoluminescence dosimeter/dosimetry

1. INTRODUCTION

R2471 defines an *unsealed source* as "any Group IV hazardous substance that is not a sealed source". A *sealed source*, in turn, is defined as "a Group IV hazardous substance that is firmly bonded within solid inactive material or sealed in an inactive capsule of sufficient mechanical strength to exclude the possibility of contact with such substance and of the dispersion thereof into the environment under foreseeable conditions of use and wear; but this definition shall not apply where such bonding or encapsulation is solely for the purpose of storage, transport or disposal".

The above definitions indicate that the additional radiation hazards in the case of unsealed sources lies in the likelihood of direct contact with the radioactive substance and of its dispersion into the environment. In dealing with unsealed radioactive materials, special attention must be paid to internal radiation hazards (via inhalation, injection or ingestion). The extent of the precautions to be taken will depend upon factors such as the **type of nuclide** used, the nature of the operations (**category of work**), and the **activity** (quantity) that is used. Other factors to be taken into consideration are the **specific activity** (concentration) of the nuclide, the **radiotoxicity and chemical toxicity**, as well as other chemical and physical properties of the material (e.g. **volatility** and **flammability**).

1.1 Purpose

For the purposes of this Code of Practice, any radioactive material may be considered to be unsealed if it is in a form that allows it to be readily removed from its container and subdivided or dispersed; in other words, radioactive material in a form that gives rise to a risk of external or internal contamination.

This Code is intended as a guide to all persons using such materials. It describes the procedures by which the provisions of the relevant legislation are administered and discusses hazards that may be encountered as well as practical precautions against them. This Code is not intended to be a detailed laboratory manual: at least an elementary knowledge of radiation and radioactivity is assumed. Further detailed information on many points can be found in the publications listed in the References.

When dealing with unsealed radioactive materials, special attention must be paid to internal radiation hazards. The extent of the precautions to be taken will depend upon a number of factors, such as the type

1 R247: Regulations relating to Group IV Hazardous Substances, made in terms of section 29 of the Hazardous Substances Act 15 of 1973 and published under Government Notice R247 in Government Gazette 14596, dated 26 February 1993.

of nuclide used, the nature of the operations (category of work), and the activity (quantity) that is used. Other factors that must be taken into consideration are the specific activity (concentration) of the nuclide, the radiotoxicity and chemical toxicity, as well as other chemical and physical properties of the material (e.g. volatility and flammability).

1.2 Scope

This Code of Practice outlines the general precautions that persons must take when carrying out work with unsealed radioactive material.

2. GENERAL REQUIREMENTS FOR EQUIPMENT AND FACILITIES

2.1 The design of facilities and associated equipment for work with unsealed radionuclides, and the general working procedures, must be aimed at:

2.1.1 minimising the exposure of staff

2.1.2 protecting visitors and workers in the vicinity of the workplace

2.1.3 controlling the spread of radioactive material into the working environment

2.1.4 controlling and minimising the spread of radioactive material and waste into the greater environment.

2.2 For all types of radioisotope facilities there are certain common requirements concerning the interior design and equipment. The walls, floor and work surfaces must be of impermeable material and must be easy to clean. The material must furthermore have good thermal and chemical resistance to the substances that are normally used in the laboratory.

2.3 Special consideration should be given to fireproof construction of buildings in which radioisotopes are used or stored. Conventional brick-wall construction is most suitable for the facilities described below. Modular construction (movable panels) should be avoided as it is very difficult to convert a room of this design into a radioisotope laboratory.

2.4 Facilities should preferably be inspected and approved before applications for authorisation are submitted. The user should contact the nearest regional Radiation Control office to arrange for an inspection to be carried out.

2.5 The authority holder must provide persons working with unsealed radioactive material with

suitable protective clothing such as laboratory coats, overalls, gloves, safety glasses and overshoes.

2.6 Disposable paper towels must be available for general use in the laboratory.

2.7 All facilities where unsealed radioactive material is handled or stored must display notices prohibiting the following practices:

2.7.1 Eating, drinking, smoking, and the application of cosmetics;

2.7.2 The pipetting by mouth of any liquid containing radioactive material.

2.8 Radiation warning signs must be posted on the doors of all facilities in which radionuclides are used or stored (e.g. on laboratory doors, doors of storage facilities, etc.). The name and telephone number of a person to be contacted in the event of an emergency must also appear on all storage facilities.

2.9 A sign indicating the class and/or type of facility (e.g. "Type B Laboratory", "Counting Room", etc.) must be displayed at the entrance to the facility

2.10 Any person who is likely to receive a whole-body dose in excess of about 5 mSv (a quarter of the annual dose limit for radiation workers) must wear personal dosimetry (TLD badges - obtainable from the SABS Radiation Protection Service, among others). If any doubt exists as to whether personal dosimetry is required, personnel should wear TLD badges for 6 months to a year, in order to ascertain whether their doses are likely to exceed 5 mSv. As a general rule, workers in A and B type laboratories require such dosimetry.

2.11 In cases where the dose to the hands is likely to be more limiting than the whole-body dose (e.g. when handling beta emitters, or when handling unsealed sources behind lead glass where the body will be protected, but the hands will be exposed to relatively high levels of radiation) it is recommended that finger TLDs be worn for a period of time, in order to establish whether dose rates to the hands should be routinely monitored.

2.12 Any area where:

2.12.1 activities in excess of C laboratory limits are handled; and

2.12.2 normal working conditions, including the possible occurrence of minor mishaps, require the workers to follow well-established procedures and practices aimed specifically at

controlling radiation exposure; and

2.12.3 the annual doses are likely to exceed 6 mSv or three-tenths of the occupational dose limits for the lens of the eye, the skin and the extremities;

2.12.4 must be designated as a controlled area and must be clearly marked as such. Only classified workers (workers subject to special medical surveillance and appropriate personal dosimetry) may be permitted unrestricted access to controlled areas.

2.13 The furniture in radioisotope facilities must be reduced to a minimum and should be easy to clean and decontaminate.

2.14 Routes of entry and exit for ventilating air should be clearly defined under all conditions of use, including open and closed positions of doors and windows and various operating arrangements of fume hoods. The siting of exhaust vents must be such as to prevent recirculation of exhausted air and must prevent the exhausted air from entering adjacent rooms.

2.15 Laboratories must be provided with enough refuse bins to allow for appropriate segregation of solid waste. The latest version of the Code of Practice for the Management and Disposal of Non-Nuclear Radioactive Waste issued by SAHPRA Radiation Control must be consulted in this regard. (See References.) The bins must have foot-operated lids and must be lined with removable plastic bags to facilitate the removal of waste without causing contamination. All receptacles for radioactive waste must be clearly identified (e.g. as low-level radioactive waste or non-active waste), and active bins must be marked with standard radiation warning signs.

2.16 When large activities are handled or stored, appropriate monitoring equipment such as a contamination monitor and an exposure rate meter must be purchased.

3. CLASSIFICATION OF RADIONUCLIDE FACILITIES

Facilities for unsealed sources are generally classified as one of the following: laboratories, counting rooms, administration rooms (in-vivo), storerooms or isolation rooms. For convenience, laboratories are further classified into Type A, B and C laboratories. Table 1 below indicates maximum activities of radionuclides that may be handled in each type of laboratory ***at any one time***. "ALI_{min}" values for each individual nuclide are specified in Appendix 1.

Table 1: Summary of activity limits in radionuclide laboratories

	A Lab	B Lab	C Lab
Max activity that may be used for Category I work	Unlimited	100 ALI_{min}	$ALI_{min}/10$
Max activity that may be used for Category II work	Unlimited	1000 ALI_{min}	ALI_{min}
Max activity that may be used for Category III work	Unlimited	10 000 ALI_{min}	10 x ALI_{min}

Category I work : Work with radioactive powders (i.e. dry and dusty) or radioactive gas.

Category II work: Wet operations (labelling procedures, chemical analyses).

Category III work: Very simple wet operations (subdivision of mother solutions).

For example, one may use up to 1 MBq of I-125 in a labelling procedure in a C laboratory, or one may use 500 MBq of P-32 at one time in a dry or dusty operation in a B-lab. If two people are simultaneously performing identical operations with the dry and dusty P-32 in the B lab, they could thus handle a maximum of only 250 MBq each.

If more than one nuclide is to be used in a laboratory, the following equation must be satisfied:

$$\sum_{K} \frac{A_k}{A_{maxk}} < 1$$

where A_k is the activity of the nuclides, and A_{maxk} the maximum activity limit for each nuclide that may be used in that facility.

Example: 14 MBq C-14 and 2 MBq P-32 are used simultaneously in wet operations in a C laboratory. Is this acceptable?

$$\sum_{k} \frac{A_k}{A_{maxk}} = \frac{14\ \text{MBq}}{40\ \text{MBq}} + \frac{2\ \text{MBq}}{5\ \text{MBq}} = 0.75$$

which is <1.

This situation is therefore acceptable.

4. TYPE A RADIOSOTOPE LABORATORY

4.1 This type of laboratory should be specially designed for the purpose for which it will be used. SAHPRA Radiation Control must be consulted beforehand.

4.2 Extremely high activities may be handled in A laboratories provided that the necessary precautions are taken to ensure that exposure limits are not exceeded.

4.3 Type A laboratories, e.g. isotope production laboratories, typically incorporate lead-glass "hot cells" equipped with remote-handling manipulators to protect workers from external radiation associated with these high activities.

5. TYPE B RADIOISOTOPE LABORATORY

Type B is the main type of laboratory at hospitals and scientific research institutions. In many cases type B is synonymous with what is called a "hot laboratory", where the main isotope work is carried out and where storage of radioactive material may also take place. When new laboratories are being planned for medical care or research, the isotope laboratory should be planned as a type B laboratory.

Type B laboratories must comply with the following minimum requirements:

5.1 Floors, walls and working surfaces

Floors, walls and work surfaces must be smooth and non-absorbent to facilitate cleaning and decontamination. Ceilings should be similarly surfaced. Floor covering must be non-slip and must (after welding if necessary) be in one continuous sheet.

The junction of floors, walls and work surfaces must be rounded off to facilitate cleaning. Corners, cracks and rough surfaces must be avoided. Where joints are unavoidable they should be placed where the risk of spills and splashes is small and must be filled with a sealing compound.

All working surfaces must additionally be able to support the weight of the necessary shielding against gamma radiation. (One m^2 of lead brick wall 50 mm thick weighs 570 kg).

5.2 Sinks and plumbing

One sink must be allocated for liquid radioactive waste (and so marked). This sink must have a resilient non-permeable surface e.g. polypropylene, PVC or stainless steel. The drains must be connected as directly as possible to the main sewer. Connections to open channels, and the use of large traps, must be avoided. All traps must be accessible for monitoring.

A separate (non-active) hand wash basin, fitted with foot-, knee- or elbow-operated taps must be provided near the exit of the laboratory, as specified in paragraph 5.

5.3 Fume hoods

A well-ventilated fume hood must be provided with the gas, water and electrical controls operable from the outside of the fume hood. The air velocity in the fume hood must be at least 0.5 m/s in the normal working position. Extractor fans should be positioned close to the outlet in order to maintain a negative pressure throughout the duct, and the motor should be outside the duct. There must be a light on the fume hood, indicating whether the fume hood is activated or not.

The surfaces of the fume hood and the ventilation duct must be smooth and non-absorbent and consist of materials that withstand the chemicals that are normally used in the fume hood. The fume hood should be provided with a sink, and a filter should be fitted in the outlet duct.

5.4 Lighting and ventilation

The laboratory must be well lit and ventilated, with a ventilation rate of at least 12 air changes/hour. A laboratory provided with a fume hood is normally ventilated by continuous movement of air into the fume hood. If work is to be permitted in the laboratory when the fume hood is switched off, additional ventilation must be provided to ensure that the required air change rate is met.

Lights should preferably be of the recessed type so that they can be mounted flush with the ceiling.

5.5 Air conditioning

Room ventilation and air conditioning must be of such a nature that they prevent recirculation of exhausted air from rooms where radionuclides are used, and which could under accident conditions become contaminated, into inactive areas or into the central air conditioning system of the hospital

5.6 Personnel monitoring

An area near the exit of the laboratory must be demarcated to provide space for changing coats, shoes, gloves, etc. A contamination monitor and basin for hand washing must be provided in this area.

All workers in B laboratories must be provided with personal dosimeters (TLD badges), unless they are specifically exempted. If beta emitters such as P-32 are handled, wearers should be provided with finger or wrist TLDs.

Routine bioassays (e.g. whole body or thyroid counting, urine analysis) should be considered if large quantities of volatile sources are handled.

5.7 Monitoring equipment

Regulation 11 of R2472 requires that an authority holder must measure radiation and contamination levels. In the case of a nuclear medicine department where unsealed radionuclides are being used, the authority holder must have both a radiation monitor and a contamination monitor.

6. TYPE C RADIOISOTOPE LABORATORY

A good chemical laboratory (classified as a type C laboratory according to IAEA specifications) will suffice for work with "type C" activities. In addition to the general requirements listed in section 2, C laboratories must comply with the following minimum requirements:

6.1 Floors, walls and working surfaces

The junction of floors and walls should preferably be rounded off to facilitate cleaning. Corners, cracks and rough surfaces should be avoided.

6.2 Sinks

The laboratory must be fitted with at least one sink with elbow-, knee- or foot-operated taps. Unless there are valid reasons to the contrary, the laboratory must be provided with a second sink to can be used exclusively for the washing of contaminated glassware and for the disposal of low-level radioactive waste. Connections to open channels should be avoided.

6.3 Lighting and ventilation

The laboratory must be well lit and must have a ventilation rate of between 8 and 12 air changes/hour.

6.4 Demarcation of work areas

Wherever possible, a type C laboratory should be dedicated exclusively for work with radioactive material. Where this is not practicable, specific areas of the laboratory must be reserved for work with radioactive material and must be clearly demarcated as such.

7. COUNTING ROOMS

A room set aside purely for the use of an alpha, beta or gamma counter must meet the following requirements:

7.1 The floor must be of impermeable material and must be easy to clean. Corners, cracks and rough

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2 R247: Regulations relating to Group IV Hazardous Substances, made in terms of section 29 of the Hazardous Substances Act 15 of 1973 and published under Government Notice R247 in Government Gazette 14596, dated 26 February 1993.

surfaces should be avoided.

7.2 The walls should be covered with non-absorbent paint.

7.3 No preparation work may be done in a counting room, and radioactive material may not be stored in such a room.

8. ADMINISTRATION ROOMS AND IN-VIVO APPLICATIONS

In-vivo applications include both diagnostic and therapeutic medical procedures involving the administration of unsealed radionuclides to patients. The facilities required will depend on the nature of the work to be performed. For instance, if patient doses are received in the form of pre-prepared sealed capsules for oral administration, or sealed vials for intra-venous administration, requirements will be less stringent than in the case where *preparation* work such as labelling, dilution, or subdivision must be done prior to administration.

8.1 General requirements for in-vivo work

8.1.1 All preparation work must be performed in a radioisotope laboratory. The type of laboratory will depend on the activities handled, and the type of work performed (i.e. work category – see section 6). Where the doses of radioactive material are dispensed and handled within a "closed" system (e.g. the milking of Tc-99m from a generator) their preparation may be considered to be category III type work. Thus, for instance, up to 9.99 GBq (270 mCi) of Tc-99m could be dispensed (i.e. handled) in a C-laboratory at any one time. Activities in excess of this may be stored in the laboratory, provided that the requirements specified in section 13 (for storerooms) are met.

8.1.2 Laboratories in which such preparation work takes place must meet the applicable requirements laid down in this code. However, allowances will be made in certain instances if the prescribed requirements for radiation safety conflict with requirements for aseptic or "clean" conditions. For example:

8.1.3 Where sinks might promote biological contamination of pharmaceuticals, they could be situated immediately outside the laboratory instead of inside the room.

8.1.4 In the case of type B laboratories, the required fume hood might in some cases increase the risk of biological contamination to an unacceptable level. (For example, it is not usually considered appropriate to store isotope generators in fume hoods.) In such cases, it is recommended that a laminar airflow (LAF) cabinet be installed instead of a fume hood. Such cabinets should have either a down-flow or a modified cross-flow pattern.

8.1.5 Rooms in which diagnostic images are taken (e.g. gamma camera rooms) must at least meet the requirements laid down for "counting rooms" in section 10.

8.1.6 An isotope calibrator must be available to control the activity administered to a patient. The calibrator should be checked daily before use with a sealed test source. Detailed and accurate records must be kept of amounts of radionuclides administered.

8.1.7 Where therapeutic doses are administered, an exposure meter must be available for monitoring the dose rate from the patient, in order to establish whether hospitalisation is necessary and to quantify the time and distance limits for staff and family who may attend the patient in hospital.

8.1.8 Any person who is likely to receive a whole-body dose higher than 5 mSv (i.e. a quarter of the annual dose limit) must wear personal dosimetry (TLD badges). Most people involved in the preparation and administration of radiopharmaceuticals for use in in-vivo diagnosis or therapy, or who are involved with the handling of patients who have received therapeutic doses, would be required to wear TLD badges.

8.1.9 Wherever possible, tongs, forceps and injection shields must be used when handling sources. Additional shielding, such as lead bricks, lead glass or Perspex (for beta-emitters) must be used to further reduce external radiation levels. Lead bricks should be painted or coated in some manner (to prevent lead poisoning) and should be firmly secured.

8.1.10 If gases (e.g. xenon) are used, care must be taken to ensure that the gas exhaled by the patient is released directly to the open air or is collected for later release. If the exhaled gas is stored for decay, it must be stored in a well-ventilated area.

8.1.11 If amounts of radioactive material administered will result in a total integrated dose exceeding 5 mSv (0.5 R) at one metre from the patient in a year, facilities must be available for the hospitalisation of the patient, and a separate toilet must be provided. Sources with short half-lives used for diagnostic purposes would not usually necessitate hospitalisation.

8.1.12 The guidelines concerning the release of therapy patients laid down in NCRP publication 37, *Precautions in the Management of Patients who* have *received Therapeutic Amounts of Radionuclides*, must be followed.

8.2 Administration rooms

8.2.1 Rooms where no preparation work takes place, but where radioisotopes are administered to

patients, must meet all the requirements specified for a type C laboratory, other than those relating to ventilation. Good ventilation in such rooms is, however, strongly recommended.

8.2.2 The working surfaces must additionally be able to support the weight of any necessary shielding material.

8.2.3 In cases where therapeutic doses are administered, a contamination monitor must be available for routine monitoring of working surfaces, and for use in the event of any accidental spillage. This monitor must also be used by personnel to check their hands, clothes, and shoes for radioactivity on leaving the laboratory.

9. RADIOIMMUNOASSAY (RIA) LABORATORIES

RIA laboratories must meet all the requirements for a type C laboratory, other than those relating to ventilation.

10. STOREROOMS

Radioactive material can be stored in radioisotope laboratories, but wherever possible it is preferable to allocate a separate room for storage purposes. The following minimum requirements are laid down for storage facilities:

10.1 The floor, walls and shelves of the room must be of impermeable material and easy to decontaminate. Open cracks, joint and sharp corners must be avoided.

10.2 If necessary (e.g. if large quantities of gamma-emitting sources are stored) the storeroom must incorporate shielding to ensure that radiation levels are kept within acceptable limits.

10.3 The storeroom must be locked to prevent unauthorised entry but should be provided with a suitable means of exit that can be operated from the inside.

10.4 The storeroom should be equipped with an extractor fan that facilitates at least 8 air changes per hour. The control switch must be situated outside the room, so that it can be activated before entering the room.

10.5 Firefighting equipment must be available if flammable material is stored, and such material should be stored in a separate part of the facility.

10.6 If activities exceeding 10 ALImin are stored, the storeroom (or laboratory) must be of a fire-resistant

construction and must be designated as a "controlled area". A contamination monitor must be available for use by personnel entering the room, and consideration should also be given to purchasing a dose rate meter.

10.7 A written inventory must be kept of the radioactive material in the storage facility. This record must clearly indicate withdrawals from, and additions to, the radioactive stock.

Example: 2 GBq of tritiated water, 80 MBq of C-14 and 90 MBq of S-35 is kept in a storeroom. Must the area be designated as a controlled area?

$$\sum_k \frac{A_k}{A_{maxk}} = \frac{2\ \text{GBq}}{1\ \text{GBq}} + \frac{80\ \text{MBq}}{40\ \text{MBq}} + \frac{90\ \text{MBq}}{30\ \text{MBq}} = 7\ ALI_{min}$$

Thus, the storeroom need not be designated as a controlled area.

11. SAFE WORKING PROCEDURES

It is not possible to give detailed working procedures covering all types of work. The procedures will depend on many different factors, especially the amount of activity used, the specific activity, the radiotoxicity, the type and complexity of the work and the skill and knowledge of the worker. Such detailed rules and guidance can best be given by the designated radiation protection officer.

The following general procedures and requirements must be applied:

11.1 All work involving radioactive material must be carried out in such a way as to ensure that doses of radiation received are as low as reasonably achievable and do not exceed the limits laid down in Reference 2.

11.2 No eating, drinking, smoking, application of cosmetics, pipetting by mouth, or any other activity that could lead to the ingestion of active material may be permitted in areas where unsealed sources are handled or stored. No food, drink, sweets, cigarettes or cosmetics may be taken into such areas.

11.3 At least two people must always be present when significant amounts of radioactive material are being handled.

11.4 Appropriate protective clothing, such as laboratory coats, gloves, safety glasses, overalls and plastic overshoes, must be worn.

11.5 Prior to commencement of work, any cuts, abrasions or open wounds must be covered with waterproof dressing.

11.6 Working techniques must be well thought out and understood before work is undertaken. Practice runs with non-active material must be carried out to ensure that operations are performed speedily and confidently, with minimum exposure and risk of accidents. A balance should be struck between hurried manipulations, which may cause accidents, and prolonged operations, which may lead to excessive exposure.

11.7 Quantities of radionuclides, and specific activities used, must be as low as is reasonably achievable. Where a non-radioactive alternative exists for a particular procedure, the radioactive option should be selected only if the added benefit gained from it outweighs the relative disadvantages.

11.8 Working surfaces must be covered with disposable material (e.g. Benchkote). Manipulations must be carried out over trays made of non-absorbent substances (e.g. stainless steel), lined with absorbent material (e.g. paper towel). Wherever possible, radioactive material must be moved or carried only within secondary containment.

11.9 Disposable handkerchiefs (e.g. tissues) must be used for nose blowing.

11.10 Vessels containing radioactive material must be covered when not in use, and must be adequately marked. As far as possible, vessels and equipment used for radioactive work should be reserved exclusively for such purposes.

11.11 When quantities of material exceeding the limits for type C laboratories are handled, the work must be performed in a fume hood.

11.12 When maintenance work is performed on pipes, ducts, or sink traps in a radioisotope laboratory, a contamination monitor must be used to check on radiation levels prior to, and during the course of, such work.

11.13 Before leaving a radioisotope facility, workers must:

11.13.1 Remove gloves in such a way as to prevent contact between the potentially contaminated outer surface and the skin.

11.13.2 Remove protective clothing.

11.13.3 Wash hands thoroughly.

11.13.4 Monitor hands, clothing and shoes (unless specifically exempted from this requirement). If contamination levels exceed those specified in Table 2 below, decontamination procedures must be carried out as described in paragraphs 16.10 to 16.15.

12. DISPOSAL

Disposal of unsealed radioactive material must be carefully controlled and must be carried out in accordance with the requirements of SAHPRA Radiation Control (see Reference 1).

13. CONTAMINATION CONTROL

It is a requirement for type A and B laboratories, and a recommendation for type C laboratories, that systematic monitoring be carried out to ensure that contamination levels do not exceed the levels specified in Table 2 below:

Table 2: Safe limits of contamination for laboratories

	"Inactive areas": parts of the body, clothes, etc	**Active areas:** protective clothing, glassware, etc.
Alpha emitters	0.3 Bq/cm^2	3 Bq/cm^2
Beta/gamma emitters	3 Bq/cm^2	30 Bq/cm^2

The measurement may be averaged over 100 cm^2.

13.1 Equipment and work areas

13.1.1 Monitoring must be performed after the completion of work; if necessary, also several times during the work, and at least once a week. Contamination levels may not exceed those specified in Table 2, except inside contained workstations (e.g. fume hoods or glove boxes), where levels must simply be as low as is reasonably achievable. Records must be kept of the results of routine monitoring of the workplace.

13.1.2 Monitoring should be performed both with the help of counting instruments and by smear tests. Geiger-Muller counters are suitable for examining the smear samples taken; the presence of alpha-emitters or very soft beta-emitters may make an alpha monitor or liquid scintillation counter necessary.

13.1.3 When alpha or soft beta emitters are used, the walls of beakers, bottles, pipettes, etc. may absorb

most of the radiation, so it is not enough to monitor only the outside of such containers.

13.1.4 Equipment should be cleaned by washing with detergents followed, if necessary, by the use of complexing agents or ultrasonic methods. Equipment that cannot be decontaminated below prescribed levels or retained until the activity has decayed below the prescribed levels, and for which no further use can be found (e.g. in more active areas), should be discarded as radioactive waste.

13.2 Spillages of radioactive material

13.2.1 Local procedures for dealing with spills must be drawn up and posted at the workplace.

13.2.2 All spillages, or suspected spillages, must be reported to the responsible person. Any serious spillages or incidents must be reported to the Department. Spillages or other incidents which cause levels of contamination that cannot be reduced to below the safe limits specified in Table 2, must be considered as "serious".

13.2.3 Absorbent paper should be laid immediately over a wet spill. Dry spills should preferably be removed by wet methods, using wet absorbent paper to prevent dispersion, if necessary. Swabbing should always be done inwards toward the centre of the spill. Any paper used should then be placed in an appropriate waste receptacle and the affected area monitored.

13.2.4 Decontamination should be carried out until the surface levels are below the appropriate limits given in Table 2. If contamination levels cannot be sufficiently reduced, the surface should be stripped or covered.

13.2.5 In all of these operations, great care should be taken to avoid spreading of the radioactivity and to prevent contamination of clothing, skin and monitoring instruments.

13.3 Decontamination of personnel

13.3.1 In the case of personnel decontamination, cleaning methods that seriously damage the skin (such as vigorous brushing) must be avoided. If washing with mild soap and water is not effective, a detergent or chelating agent specific to the chemical form of the contaminant should be used. Moderate activity that remains fixed to the skin after cleaning may be less harmful than the use of harsher decontamination measures.

13.3.2 Great care should be taken during decontamination of the face or hair to avoid spreading contamination, particularly to the lips, nose and eyes. If the eyes require irrigation, adjacent skin

should first be decontaminated to prevent such contamination from being washed into the eyes. The eyes should be irrigated outwards to avoid contamination of tear ducts.

13.3.3 If corrosive or other toxic materials are present in addition to radioactive contaminants, the usual first-aid measures should be applied before attempting to carry out radioactive decontamination.

13.3.4 If the skin is accidentally broken when working with radioactive materials, the wound should be irrigated immediately with tap water, the edges of the gash being spread to assist the flushing action of the water and to encourage bleeding. Serious wounds must be referred to the appointed doctor for further attention.

13.3.5 In the case of an accidental intake of radioactive materials, which it is believed may lead to a significant dose of internal radiation, the appointed doctor must be contacted immediately, followed by a notification to SAHPRA Radiation Control. Pending arrival of the doctor, certain simple first-aid measures may be applied to assist in the elimination of the radioactivity. These include the cleansing of the nasal passages, the expectoration of saliva and perhaps in some cases, the induction of vomiting.

13.3.6 Any article of protective clothing or personal clothing found to be contaminated must be washed separately and with due care. For articles contaminated with short-half-life nuclides, storage for decay is recommended. If, despite washing and/or storage, contamination levels cannot be reduced to the levels prescribed in Table 2, the article or garment must be disposed of as radioactive waste.

14. REFERENCES

The following related documents are referenced:

14.1 *Code of Practice for the Management and Disposal of Non-Nuclear Radioactive Waste.* SAHPRA Radiation Control. (Update in progress at the time of publication of this document).

14.2 *Ionising Radiation Dose Limits and Annual Limits on Intake of Radioactive Material*. Directorate: SAHPRA Radiation Control. (Update in progress at the time of publication of this document).

14.3 *R247*: Regulations relating to Group IV Hazardous Substances, made in terms of section 29 of the Hazardous Substances Act 15 of 1973 and published under Government Notice R247 in Government Gazette 14596, dated 26 February 1993.

15. VALIDITY

This Code of Practice is valid for a period of 5 years from the effective date of revision and replaces the old *Requirements for the Safe Use of Unsealed Radioactive Nuclides [UNSEAL], revised April 1994.* It will be reviewed on this timeframe or as and when required.

16. APPENDICES

16.1 Appendix 1: The Concept of ALI_{MIN}

ALIs (annual limits on intake) are prescribed in ICRP Publication 61, *Annual Limits on Intake of Radionuclides by Workers Based on the 1990 Recommendations*. The limits have been set paying regard to the ICRP's new annual dose limit, 20 mSv (2 rem). There are different ALI values for ingestion and inhalation. ALI_{min} for each nuclide means the lesser of these two values.

Table 3 shows the values for ALI_{min} for the most common radionuclides. For nuclides not included in the table, the SAHPRA Radiation Control specifies applicable values.

Table 3: ALImin values for some common radionuclides

Nuclide	ALI_{min} (Bq)	ALI_{min} (Ci)
^{3}H water	1.10^{9}	27 mCi
^{14}C	4.10^{7}	1 mCi
^{18}F	4.10^{8}	11 mCi
^{22}Na	7.10^{6}	189 µCi
^{24}Na	5.10^{7}	1.4 mCi
^{32}P	5.10^{6}	135 µCi
^{33}P	3.10^{7}	810 µCi
^{35}S	3.10^{7}	810 µCi
^{36}Cl	3.10^{6}	81 µCi
^{38}Cl	2.10^{8}	5.4 mCi
^{42}K	5.10^{7}	1.4 mCi
^{43}K	9.10^{7}	2.4 mCi
^{45}Ca	1.10^{7}	270 µCi
^{47}Ca	1.10^{7}	270 µCi
^{51}Cr	2.10^{8}	5.4 mCi
^{52}Mn	1.10^{7}	270 µCi
^{52m}Mn	3.10^{8}	8.1 mCi

Nuclide	ALI_{min} (Bq)	ALI_{min} (Ci)
^{57}Co	8.10^{6}	216 µCi
^{58}Co	7.10^{6}	189 µCi
^{60}Co	4.10^{5}	11 µCi
^{63}Ni	1.10^{7}	270 µCi
^{64}Cu	2.10^{8}	5.4 mCi
^{67}Cu	5.10^{7}	1.4 mCi
^{62}Zn	2.10^{7}	540 µCi
^{65}Zn	4.10^{6}	110 µCi
^{69m}Zn	5.10^{7}	1.4 mCi
^{67}Ga	8.10^{7}	2.16 mCi
^{68}Ga	2.10^{8}	5.4 mCi
^{73}As	2.10^{7}	540 µCi
^{74}As	9.10^{6}	243 µCi
^{75}Se	9.10^{6}	243 µCi
^{76}Br	5.10^{7}	1.4 mCi
^{77}Br	2.10^{8}	5.4 mCi
^{82}Br	4.10^{7}	1.1 mCi

^{54}Mn	1.10^{7}	270 µCi
^{56}Mn	9.10^{7}	2.4 mCi
^{52}Fe	1.10^{7}	270 µCi

^{81m}Rb	2.10^{9}	54 mCi
^{81}Rb	4.10^{8}	11 mCi
^{86}Rb	8.10^{6}	216 µCi

Nuclide	ALI_{min} (Bq)	ALI_{min} (Ci)
^{55}Fe	3.10^{7}	810 µCi
^{59}Fe	5.10^{6}	135 µCi
^{56}Co	2.10^{6}	54 µCi
^{85}Sr	1.10^{7}	270 µCi
^{87m}Sr	7.10^{8}	19 mCi
^{89}Sr	2.10^{6}	54 µCi
^{90}Sr	6.10^{4}	1.6 µCi
^{90}Y	5.10^{6}	135 µCi
^{99m}Tc	1.10^{9}	27 mCi
^{99}Mo	1.10^{7}	270 µCi
^{113m}In	9.10^{8}	24 mCi
^{124}Sb	3.10^{6}	81 µCi
^{123}I	9.10^{7}	2.4 mCi
^{125}I	1.10^{6}	27 µCi
^{129}I	2.10^{5}	5.4 µCi
^{130}I	1.10^{7}	270 µCi
^{131}I	8.10^{5}	22 µCi
^{132}I	7.10^{7}	1.9 mCi
^{109}Cd	1.10^{6}	27 µCi
^{115}Cd	1.10^{7}	270 µCi
^{111}In	5.10^{7}	1.4 mCi
^{129}Cs	3.10^{8}	8 mCi

Nuclide	ALI_{min} (Bq)	ALI_{min} (Ci)
^{88}Rb	2.10^{8}	5.4 mCi
^{89}Rb	4.10^{8}	11 mCi
^{85m}Sr	4.10^{9}	108 mCi
^{134m}Cs	1.10^{9}	27 mCi
^{137}Cs	1.10^{6}	27 µCi
^{131}Ba	4.10^{7}	1 mCi
^{133m}Ba	3.10^{7}	810 µCi
^{135m}Ba	4.10^{7}	1 mCi
^{140}La	8.10^{6}	216 µCi
^{169}Yb	9.10^{6}	243 µCi
^{192}Ir	3.10^{6}	81 µCi
^{198}Au	1.10^{7}	270 µCi
^{197}Hg	6.10^{7}	1.6 mCi
^{203}Hg	1.10^{7}	270 µCi
^{201}Tl	3.10^{8}	8 mCi
^{204}Tl	3.10^{7}	810 µCi
^{210}Pb	1.10^{4}	270 nCi
^{212}Pb	5.10^{5}	14 µCi
^{210}Po	1.10^{4}	270 nCi
^{226}Ra	9.10^{3}	243 nCi
^{232}Th	9.10^{1}	2.4 nCi
^{238}U	6.10^{2}	16 nCi

^{130}Cs	7.10^{8}	19 mCi
^{131}Cs	3.10^{8}	8 mCi
^{134}Cs	1.10^{6}	27 µCi

^{241}Am	3.10^{2}	8 nCi
^{244}Cm	5.10^{2}	14 nCi
^{252}Cf	5.10^{2}	14 nCi