RP CoP006 - Working with Unsealed Radioactive Material

1. Introduction

This Code of Practice outlines the general precautions that persons must take when carrying out work with unsealed radioactive material. Unsealed means radioactive material in such a form as to give rise to a risk of external or internal contamination.

2. Justification and Optimisation

Before anyone uses radiation or radioactivity it is a prerequisite that the use is justified. Workers must consider carefully:

- Whether they need to carry out the work;
- Whether radioactivity is needed;
- Whether the work can be carried out with an alternative, non-radioactive, tracer; and
- What health and safety implications there are of any alternative methods.

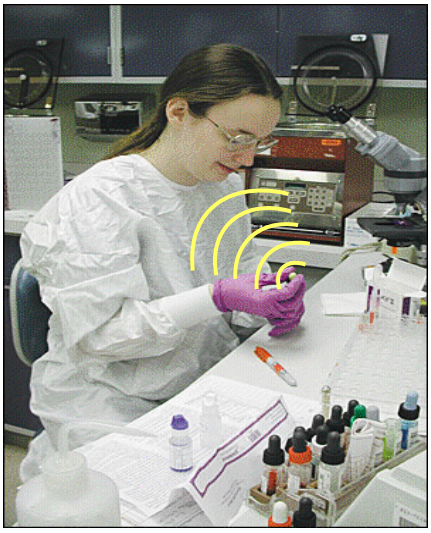
These should be carefully thought through and recorded; it might be necessary to explain this justification to an Enforcing Authority.

Once the decision to use radioactivity has been made, the worker must also consider the choice of radioactivity so as to minimise the risk; this is known as Optimisation. The following matters should be considered:

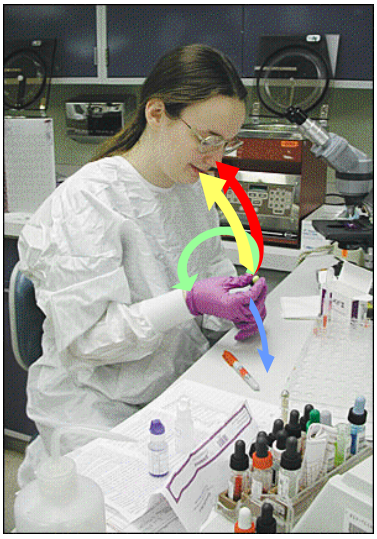
- Can beta emitting radionuclides be used in preference to gamma or alpha emitters;
- What radionuclide will give the lowest energy emissions consistent with achieving the end result, and with adequate detection of the nuclide;
- What is the minimum quantity necessary to achieve the end result; and
- What physical and chemical form of the radionuclide best reduces the risk of internal and external exposure?

3. Risk

Depending upon the quantity and isotope, unsealed radioactive material can emit significant levels of radiation, causing exposure of those who work with it or are in the vicinity. This is known as external radiation. In addition, unsealed radioactive material might enter the body by skin absorption, inhalation or ingestion. This is known as internal radiation. Radioactive material inside the body will irradiate tissue at high levels since it is in such close contact with the tissue. It is also very much more difficult to remove. The dose can vary enormously depending upon the chemical behaviour of the radioisotope in the body.



External Radiation risk



Internal Radiation risk

Work with unsealed radioactive material always requires control measures to reduce the risk of radioactive material getting on or in the body. This is known as contamination control. In addition, some radionuclides might present an external radiation risk and precautions will be needed against this.

4. Contamination Control

The aim of contamination control is to both avoid getting radioactive material onto the surface of the body and to prevent the intake of the material into the body by whatever means. This is achieved by the use of the following control measures

4.1 Working area and facilities

Radioactive material must only be used within a clearly demarcated area so that all persons are clear where it is being used and where it is not. Although working procedures are designed to minimise the amount of contamination, it must be assumed that any item or surface within a radiation demarcated area could be contaminated. For very small amounts of radioactivity, the demarcation can be a simple visual aid, such as notices. As the amount of activity being used increases, so must the degree of demarcation. Small to medium amounts of radioactivity must be used in a "Supervised Area" and larger amounts in a "Controlled Area". Details of Supervised and Controlled Areas can be found in RP COP011.

The laboratory must have facilities to enable tight control on the spread of radioactive material. Except for laboratories handling large amounts of radioactivity (which are unlikely in the University) these are the same as would be found in any modern chemical or biological laboratory. The layout must minimise the need for entry by persons other than those working in the area. In laboratories handling larger quantities of radioactivity write-up areas must not be in the same area as the radioactive work, and access to offices must not be gained via the working area. The facilities must be of a design that minimises the risk of material accumulating in

cracks, be easily cleanable, have impervious surfaces, designated and suitable disposal sinks and separate wash hand basins, and accessible drain pipes etc. Sinks used for radioactive waste, and the immediate waste pipework must be marked with the radiation symbol. There must be adequate space and storage facilities. Local extract ventilation, normally through fume cupboards, might be necessary, although it should be noted that discharges of radioactive material to the atmosphere normally needs an authorisation from the Scottish Environment Protection Agency. Soap, a nailbrush, disposable towels (or hot-air drying) and disposable tissues must always be available.

Further details on radiation laboratory facilities can be found in RP COP014.

4.2 Working Procedures

Nearly all the contamination that can be transferred onto and into the human body is caused by the working procedures adopted by the individual. Good contamination control requires a great deal of thought and self-discipline, and is easily forgotten when work has to be done. (How many people would think twice about scratching an itch on their nose?) In order to reduce the risk, the following working procedures must be adhered to in the work area:

DO NOT

- eat, smoke, drink or apply cosmetics;
- use a mouth pipette;
- handle radioactive material or potentially contaminated articles unless wearing a laboratory coat and protective gloves;
- use a pocket handkerchief - rather use disposable tissues.

DO

- use self-adhesive labels;
- cover cuts or abrasions with waterproof dressings;
- avoid touching areas of uncovered skin with a gloved hand;
- use a disposable tissue when touching items with a gloved hand if there is any risk of cross contamination;
- cover working surfaces with disposable absorbent materials;
- use an extra degree of containment, such as a tray;
- use a fume cupboard if there is any risk of releasing gas, dust, aerosols, etc.

For areas handling low quantities of radioactivity, it is acceptable to use a lab coat that is also used elsewhere. For large quantities, it may be necessary to use a lab coat dedicated to the Controlled Area.

4.3 Labelling

It is essential that all radioactive material be labelled to indicate that it is so. Every container must be labelled unless it is very small, or one of many identical, such as multiple small vials. In this case the rack used to hold them must be labelled.

4.4 Monitoring

The skin, clothes and shoes must be checked for surface contamination whenever people leave a designated radiation area. It is also advisable to check for surface contamination at regular intervals and whenever some contamination might have arisen; it is essential if there is a spillage. Information on monitoring can be found in RP COP003.

The need for personal monitoring of the internal radiation hazard depends upon a variety of matters. The type of monitoring that is appropriate also depends upon the type of radionuclide and its chemical structure. Further information can be found in RP COP008. The need for and type of personal monitoring for particular work will be specified in the Radiation Risk Assessment.

4.5 Cleaning of Glassware

Contaminated glassware should be segregated and soaked in cleaning fluid before being washed in a designated sink. Radiation workers must ensure that waste materials have been disposed of and glassware decontaminated before passing to laboratory assistants for final cleaning.

4.6 Gaseous Material

Any procedures that give rise to volatile or gaseous products or dusts must be performed in a fume cupboard or glove box as appropriate. To ensure containment, the sash of the fume cupboard must be at or below the marked level. The sash should always be left in the lowest position when work is complete and the cupboard should contain only essential materials and be kept clean and tidy. There might be a need to use specialist local extract ventilation (LEV). If so, the advice of the University Radiation Protection Adviser (URPA) should be sought.

Where gaseous waste is produced deliberately, authorisation under the Environmental Authorisations (Scotland) Regulations 2018 must be obtained. Authorisation for gaseous waste would usually require a Permit.

4.7 Procedure before leaving a radiation designated area

On completion of work with radioactive materials and before leaving the laboratory, a worker is responsible for:

1. returning all sources to shielded positions and ensuring that they not left where they are likely to be spilled;
2. marking and segregating contaminated apparatus for washing;

3. checking the working area for contamination and, if necessary, decontaminating;
4. if protective clothing is contaminated, it should be discarded as waste or set aside for washing; it must not be sent to normal laundry; and
5. completing all records required.

4.8 Storage of Radioactive Material

Radioactive material must be put away into suitable storage when it is not in use. Suitable means secure, appropriate to the nature of the container and appropriately signed. The surfaces of the store must be such as to minimise the collection of contamination and to allow for easy removal of any such contamination. Shielding might be necessary.

4.9 Source Accounting

It is essential that the details and quantities of radioactive stock and disposals are known at all times and recorded. Information on this can be found in RP COP010. A robust arrangement must be in place to ensure that new radioactive material is delivered to a named individual within the premises or research unit. It is not satisfactory for material to be left in a delivery area or similar. Subsequent transfer of the material to other departments within premises must also be from person to person, and in certain cases a formal transfer signature should be obtained.

4.10 Visitors

Before cleaning staff are allowed to clean a laboratory floor, the floor must be checked for contamination and, if necessary, decontaminated. Notices are available from the URPA that can be placed on the door of the laboratory for the attention of cleaning staff to advise them whether or not the area is safe for them to enter and clean.

A permit-to-work scheme is in place for contractors and maintenance staff and details can be found on the Health and Safety website. Other visitors must be accompanied at all times by a University authorised radiation worker, who is responsible for ensuring that the visitor follows the University safe working practices and can monitor the visitor as appropriate.

4.11 Work with Animals

Work involving radioactive materials in animals is only permitted in certain rooms and parts of animal houses approved for the purpose. The cages or pens of animals involved must be marked with the radiation symbol and details of sources in use. Surfaces must be easily decontaminated and facilities must be available for the safe handling of animals and excreta.

Those attending to the animals must receive from the authorised worker adequate instruction about the hazards involved and training in the safety procedures. All

excreta should be treated as radioactive waste. The RPS will advise on necessary procedures and waste disposal.

4.12 Waste

Suitable containers must be available for the segregation of solid waste into combustible and non-combustible waste. These must be marked. It would also be advisable to mark any bins used for the disposal of non-radioactive material as such, to emphasise the difference in between the various bins. The waste must be removed regularly, either to disposal or to a separate waste store. If a mixture of short half-life and long half-life radionuclides are being used, and the short half-life material is being stored for a while to decay, it will be necessary to have separate waste bins.

Liquid waste that is miscible with water and is authorised under a relevant Permit should be disposed of in the designated sink. Care should be taken to ensure that there is free flow to the drain before disposal is made and the waste should be flushed with large quantities of water during and after disposal.

Some types of liquid scintillant can be disposed of to the drain, while others have to go for incineration.

Information on the University arrangements for the disposal of radioactive waste can be found in RP COP009.

5. External Radiation Control

Many of the radionuclides used in the University and much of the quantities handled do not give rise to significant external radiation dose rates. There are however some that emit high-energy beta radiation or significant gamma radiation, and some precautions need to be taken. It is likely that precautions against external radiation would need to be taken if working with the following radionuclides:

Sodium-24	Rubidium-86	Iodine-131
Phosphorus-32	Technetium-99m	Thallium-201
Iron-59	Indium-111	
Zinc-65	Iodine-123	

This list is only a guide - a final decision is made in the appropriate risk assessment.

Exposure to external radiation can be controlled by the use of three basic approaches:

- Control of the time of exposure;
- Control of the distance to the radioactive material and;
- The use of appropriate shielding.

5.1 Time

Time is often the most appropriate technique, especially when larger activities, such as stock solutions, are only handled in order to remove an aliquot of lower activity. Exposure and time have a straightforward linear relationship:

Dose (D) $\propto$ time of exposure (t).

As a general rule, workers should only handle radioactive material, or remain close to it, for the shortest time necessary to achieve the desired result.

5.2 Distance

Radiation reduces quickly with increasing distance by a relationship known as the Inverse Square Law:

$$Radiation\ Intensity\ (I) \propto \frac{1}{Distance(d)^2}$$

Thus if you double your distance away from a source, the radiation intensity drops by a factor of four. This relationship of course works both ways. The following table shows the change in dose rate with distance from a 10ml glass vial containing 100MBq of phosphorus-32 or technetium-99m (Emission data obtained from Radionuclide and Radiation Protection Handbook 2002, Delacroix, Guerre, Leblanc and Hickman, 2002.). The data neglects any air absorption:

Distance from vial (cm)	Dose Rate ($mSvh^{-1}$) P-32	Dose Rate ($mSvh^{-1}$) Tc-99m
100	-	2.2×10^{-3}
10	0.054	0.22
1	5.4	22
0.1	540	2200

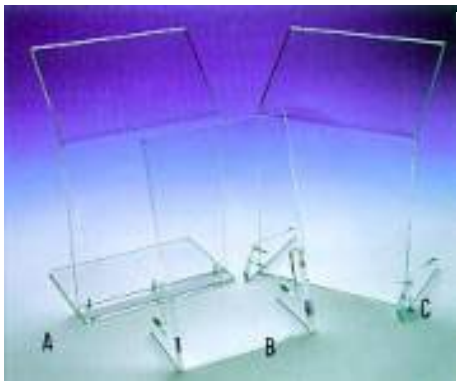
It can be seen that at close distances to the source, there are very high dose rates. It is for this reason that radioactive sources must never be picked up by the bare hand.

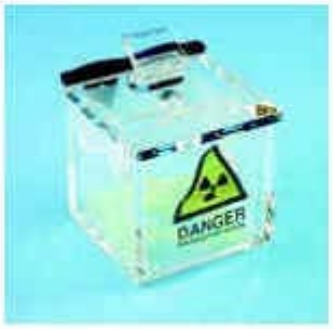
5.3 Shielding

Shielding might be needed if you are working for long periods of time close to sources, or when high activity sources are being handled. Shielding might also be needed for sources whilst in store. The type of shielding depends upon the source,

and needs to be considered for each particular situation. This would be specified in a risk assessment. The permitted radiation dose to the extremities is more than to the torso - "the whole body"-, and so it is normal when working with relatively low levels of emission to shield the whole body but not the arms and hands.

As a general rule, low density materials such as plastic should be used for beta emitters. There are proprietary shields available, and some are some shown below.





Gamma emitters require dense material, and in a laboratory environment this would normally be small lead sheets or bricks. Conventional brick or concrete walls will provide some shielding.

5.4 Monitoring

Real-time monitoring of the external radiation hazard can be carried out using appropriate dose rate meters. However, these can be expensive, and if the circumstances of the use of the radioactive material do not change, it is rarely necessary to make frequent dose rate measurements.

Personal monitoring is often used to check on radiation exposure, but some isotopes used in research laboratories are not detected by personal dosemeters, and it is important that the correct type of personal monitoring is chosen. Further information on personal monitoring can be found in RP COP008. The need for and type of personal monitoring for particular work will be specified in the returned Proposed Scheme of Work form.

6. Training and Authorisation of Staff

Those working unsupervised with radioactive material must be suitably trained. Suitable means having undergone a course in radiation safety that includes both a basic introduction and matters relevant to the use of unsealed radioactive material in laboratory research. Those who successfully pass the University of Edinburgh Basic Radiation Protection Course assessments are considered to be suitably trained. Where training has been attended at another organisation, workers may be asked to produce a record of this training. They are also required to take the Regulation Module within the Basic Radiation Protection Course, detailing legislation and University procedures. All workers must receive instruction from their Radiation

Protection Supervisor (RPS) on local matters such as local rules, operation of equipment, radiation monitor, record keeping etc.

All radiation workers must also have a Proposed Scheme of Work form that relates to their work and has been signed by their RPS and the URPA. Without this form, they are not permitted to undertake unsupervised work with radiation or radioactivity.

7. Emergency Procedures

An emergency could involve actual or potential dispersal of activity or exposure to a high dose rate or both but in any case, safety of personnel should have priority. The general procedures in case of accidents are outlined below, but they will also be found in school/unit Local Rules.

7.1 Spillage of Radioactive Material

Experience has shown that most incidents involving spills of unsealed radioactive materials do not warrant drastic action. After an assessment of the incident, simple measures should be taken to control the spread of contamination, for instance, by the use of absorbent material.

1. A notice should be placed to warn other persons to keep clear of the area.
2. If the spill involves activity greater than 4 MBq, the URPA must be informed. All accidents involving contamination of the person must be reported to the URPA, via the RPS.
3. The help of the Departmental RPS or Area Supervisor should be obtained.
4. Action should be taken to avoid the spread of contamination by marking and restricting access to the contaminated area.
5. The spread of contamination, particularly on shoes or clothing of persons leaving the affected area, should be prevented. Persons who may be contaminated should be monitored immediately outside the area and appropriate arrangements made for their decontamination.
6. Contaminated clothing should be removed and left in or near the affected area. Contaminated parts of the body should be washed thoroughly but gently until either monitoring shows that contamination will not be significantly reduced further by this, method or there is a risk of roughening or breaking the skin.
7. Any contaminated wound, however trivial, should be irrigated with water or saline solution, care being taken to limit any spread of contamination to or from other parts of the skin.
8. Persons entering the affected area to carry out emergency procedures should wear appropriate protective clothing that they should monitor and remove when they leave the area.
9. Access to the affected area should be restricted until radiation surveys show that the area may be reoccupied.

7.2 Accidents Involving Radioactivity and Injury to the Person

Any person who is suspected of having been significantly irradiated or who is injured and may be contaminated, should be taken to the Royal Infirmary, Accident and Emergency Department, who must be warned in advance to allow preparation for reception of the casualty. A responsible person aware of the details of the incident should accompany the casualty to the Infirmary. The RPS and URPA must also be informed.

7.3 Fire in Laboratories

In case of fire, normal school/unit fire drill should be followed and the RPS and URPA informed. If time allows, radioactive sources should be returned to shielded storage and fume cupboard ventilation switched off. When Fire Brigade personnel arrive, they should be advised of the significance of radiation hazard signs. Fire fighters wearing breathing apparatus can safely enter a Controlled or Supervised Area for radioactive materials.

7.4 Loss of Radioactive Material

If it appears that some radioactive material is unaccounted for or has not arrived, the RPS and the URPA must be informed. An investigation must be carried out to ascertain when the material may have become lost and where it was last known to be. If the material cannot be located within a certain period of time, it might be necessary to inform the Scottish Environment Protection Agency and the Health and Safety Executive. This will be undertaken by the URPA.

For advice on any of the above topics please contact the Radiation Protection Unit.

Document version

Version number	Summary of change	Date and by whom
V1.0	**New version**	**August 2004 Colin Farmery**
V1.1	**Minor updates**	**October 2020 LW**
V1.2	**New template**	**November 2024 JC**

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