Ionising Radiation

February 2018

Working Safely with Sealed Radioactive Sources

Occupational Health and Safety Service
HSD066R (rev 7)

UNIVERSITY OF CAMBRIDGE

Contents

APPENDICES – please refer to the Safety Office website to select individual appendices

1 Introduction

This document has been prepared by the Safety Office and sets out arrangements for control of work with sealed radioactive sources in the University of Cambridge. It also provides practical guidance on control measures and safe working with sealed radioactive sources and is aimed primarily at individual research workers and their supervisors.

This document supplements the more general arrangements for managing work with ionising radiations, including the roles of Heads of Departments and nominated Radiation Protection Supervisors which are described in the separate document *Management of Work with Ionising Radiation in the University of Cambridge.* Any person requiring further advice on work with generators should consult their research supervisor and Radiation Protection Supervisor (if appointed) in the first instance. The University's Radiation Protection Advisers at the Safety Office must be consulted over certain matters (see appendix 1) but can be consulted on any matters relating to radiation protection. The RPA must be contacted prior to ordering or acquiring a sealed source.

This document does not cover the use of unsealed radioactive sources or radiation generators. Guidance on work with radiation generators (including X ray machines) is covered by the University policy and guidance document *Working Safely with Radiation Generators* and guidance on unsealed radioactive sources is given in the University document *Working Safely with Unsealed Radioactive Sources*.

All work with Sealed Radioactive Sources must comply with the requirements of Ionising Radiations Regulations 2017 (IRR17) which are enforced by the Health and Safety Executive, and the Environmental Permitting Regulations 2016 which are enforced by the Environment Agency. Transport regulations may also apply – the University guidance is set out in *Transport and Movement of Radioactive Materials* and the RPA must be consulted.

This document will be subject to review at intervals not exceeding three years.

2 Roles and Responsibilities

The Head of Department is responsible for implementing effective safety management. The Departmental Safety Officer (DSO) advises on and coordinates safety in the department, and assists in ensuring compliance on all safety matters including radiation safety (unless this task is delegated to another member of staff in writing).

A Radiation Protection Supervisor may be appointed for some work with Ionising radiation, but if an RPS has not been appointed for the work with sealed sources refer to your Departmental Safety Officer for information on local arrangements.

Research supervisors and local managers have responsibilities in ensuring risk assessments are written, safe working procedures are followed locally and any necessary training is provided.

Radiation Protection Advisers are employed to advise the University and can be contacted at the Safety Office. A Radiation Protection Adviser must be consulted over certain aspects of work with ionising radiation under IRR17. Refer to appendix 1 for matters that require

consultation with an RPA. The RPA must be contacted prior to ordering or acquiring a sealed source.

The Radiation Protection Supervisor

The Radiation Protection Supervisor is a statutory appointee who assists the employer in complying with the Regulations and *specifically ensures that the local rules are complied with*. The RPS reports to the Head of Department on ionising radiations safety issues. The general role of the RPS is described in more detail in *Management of Work with Ionising Radiation* and normally includes the following.

1. Keeping in regular contact with research groups within their areas of responsibility.
2. Where appropriate, checking risk assessments for new work involving ionising radiations.
3. Ensuring that appropriate critical examinations are carried out and documented.
4. Where appropriate, offer practical advice and assistance to users of ionising radiations.
5. Supervising the system for testing of radiation monitoring instruments.
6. Ensuring that departmental safety procedures (department's safety policy/manual) and local rules are prepared, maintained and implemented.
7. Providing assistance in dealing with emergencies.
8. Responding when notified of specific incidents involving sealed sources, and where appropriate, supervising tests of engineering controls, safety features etc.

The Research Supervisor

The research supervisor or "line manager" will:

1. Generally, ensure that the written requirements set out in this document and in the department's safety procedures (and local rules where relevant) are complied with.
2. Cooperate with other persons in the department including the Radiation Protection Supervisors to ensure that the department's safety requirements are met.
3. Ensure that new work has been subjected to a written risk assessment agreed by themselves and the Radiation Protection Supervisor (if an RPS is appointed), and ensure that measures to restrict radiation doses, including training, are put into place.
4. Ensure that workers know that they are responsible for following the agreed practical precautions.
5. Ensure that appropriate personal protective clothing and other equipment is suitable for the work, maintained in good condition and is being worn.
6. Ensure that the agreed programme of monitoring, safety checks and record-keeping is undertaken within their area of responsibility.

The user of ionising radiations

The individual research worker (the user) will:

1. Ensure that they have registered their work with their department.
2. Take all reasonable steps to protect themselves and others that could be affected by their work.
3. Never misuse sealed sources or equipment provided to restrict exposure.
4. Cooperate with others involved in safety including their research supervisor and the RPSs.
5. BEFORE commencing any new work involving sealed sources inform their research supervisor (or line manager) and always inform the RPS (where appointed).
6. If required by the department, prepare a written risk assessment for the work, which should be approved by their research supervisor (or line manager) and the RPS (where appointed).
7. Ensure that they are aware of the underlying hazards associated with this type of work, as described in this document, local rules, and in training, etc.
8. Observe the safety precautions identified in this document and in the department's local rules, and any special precautions identified in the risk assessment, experimental protocol or by warning signs.
9. Ensure that they wear appropriate protective clothing and other equipment including personal dosimetry, as specified in the department's local rules and risk assessment.
10. Notify their research supervisor and the RPS in the event of faults or damage to equipment, of untoward exposures or of other specified incidents (refer to local rules for further information on contingency plans appropriate to the work).

3 Definition of sealed source

A sealed source is *a radioactive source whose structure is such as to prevent, under normal conditions of use, any dispersion of radioactive material into the environment.*

A similar term under previous legislation was “Closed source” but this term is no longer used.

Sealed sources are commonly contained within equipment such as irradiators, gas chromatographs and liquid scintillation counters. Individual sources are also used stand alone to test instruments or to demonstrate properties of radiation in teaching.

4 Control of work

This section sets out the arrangements for control of work which the University departments must follow. Departments should additionally consult the Radiation Protection Adviser as necessary. These arrangements must be in place *prior* to starting work.

- Prior risk assessment

  (local rules may also be required – see section 6)

  Departmental responsibility

- Holding, using and disposing of sealed sources under EPR permits or exemption provisions

  Departmental responsibility

  (Permit applications are made via Safety Office)

- Critical examinations of equipment

  Installer's responsibility

  (Departmental responsibility to check this is done – note that the department may be the installer if this is carried out by departmental staff)

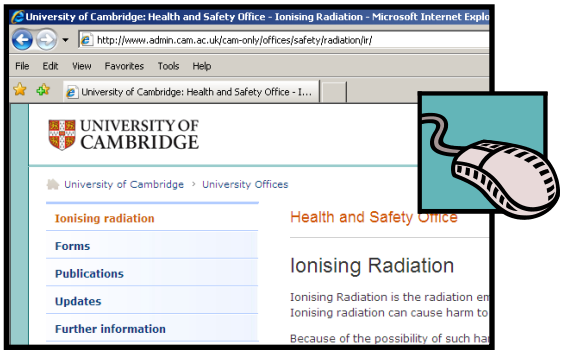
- Authorisation for work

  and ensuring that appropriate training is provided

  Departmental responsibility

Please refer to the Safety Office website or contact us directly for the latest copies of the relevant forms and publications, updates and further information.

http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/ir/



4.1 Prior risk assessment

Before any new work with sealed sources is undertaken the department must ensure that a written risk assessment is in place and that the control measures required by the risk assessment are implemented.

Adequate assessment of the risks of work with sealed sources, and recording of the significant findings of such an assessment, is fundamental to safe working and is a requirement of both the Ionising Radiations Regulations 2017 and the Management of Health and Safety at Work Regulations 2017.

Once the risk assessment is complete a copy should be held by the user in the same file as the experimental protocol or other local rules documents. Anyone directly involved in the work covered by the assessment must be familiar with its contents including any necessary control measures.

As a result of the risk assessment and information from the manufacturer, any specific safe working procedures relevant to an individual piece of work must be set out in clear and concise **local rules** and/or safe working procedures within departments. These documents should be readily accessible to users. Any general departmental arrangements may be set out in the Departmental Safety Manual, and should refer to relevant University Policy and Guidance.

Risk assessments must be recorded, and for all new work the format in appendix 2 should be used.

Risk assessments for significant new work in a department must also be passed to the Safety Office for comment by University's Radiation Protection Adviser (unless the RPA advises that this is not necessary).

Responsibility for preparing the risk assessment rests with the University. In practice, the person responsible for the work (the research supervisor or line manager) will normally carry out the risk assessment. Users should not begin new work until a risk assessment has been agreed by the research supervisor and the RPS (if an RPS has been appointed). This does not mean that a separate risk assessment needs to be prepared for every single piece of experimental work. For example, a series of experiments could be undertaken under the same risk assessment (with variations if necessary). Departments must use their own judgement in this matter and users must also follow any departmental policy.

RPSs who are familiar with the work and/or the University Radiation Officer/RPA can provide advice and assistance on preparing risk assessments for work with sealed sources.

4.2 Conditions for keeping, use and disposal of sealed sources

Departments must maintain strict controls on acquisition of sources and the requirements are set out in section 4.8 of the University Policy *Management of Work with Ionising Radiation.* This is partly to assist in ensuring that risks have been adequately assessed and appropriate control measures are in place (section 4.1 above).

The RPA must be contacted prior to ordering or acquiring a sealed source, and the department must have in place a system of authorisation to order or acquire radioactive sources. **If the RPS is the intended user, an additional written authorisation must be obtained**, for example, from another RPS or Safety Officer (who must be aware of permit limits for the department) in accordance with departmental arrangements.

Under the Environmental Permitting Regulations 2016 (EPR16) departments must ensure that sources can legally be held, that the conditions for keeping and use are met and that there is legal and workable means for disposal.

This is done through a system of *permits* or *exemption provisions* under EPR16 (EPR 2016 consolidated EPR 2010 and the 2011 exemption provision amendments). Departments must ensure that all of the conditions of relevant permits and exemption provisions are met. Please refer to section 12 for guidance on specific applications.

Permits under EPR16

Permits are issued by the Environment Agency on application, and all applications must be made via the Safety Office. The application process can take several months so must be considered in the planning stages of any new work. Permits contain specific conditions, but the following general conditions apply:

- Departments must have suitable management arrangements, including sufficient competent persons and resources to comply with your permit;
- Departments must have suitable arrangements and measures in place to maintain the security and integrity of sealed sources;
- Departments must have suitable arrangements for sources which become disused or are transferred (the Safety Office advises on and manages disposals)
- Departments must make and keep records demonstrating compliance and provide information as requested;
- Departments must submit information to the Safety Office when requested to comply with EA reporting and notification requirements.

Exemption provisions under EPR

Exemption provisions allow certain sources to be held without the need for a specific permit, but the conditions of the exemption must be followed to ensure a suitable level of control. E*xemption provisions* include limits on activity and conditions.

Exemption provisions apply to small sealed sources under the following descriptions:

- an individual sealed source of maximum activity 4MBq (and up to a limit of 200MBq on the premises in total)
- an electrodeposited source of 600MBq of Ni-63, or 200MBq of Fe-55 (up to a limit of 600GBq on the premises in total)

- sealed Tritium or Tritium electrodeposited sources up to 20GBq individually and up to a total of 5TBq.

The conditions of exemption under EPR include the need to:

- Prevent accidental removal, loss or theft of sources,
- Label sources as radioactive where practicable,
- Not modify or mutilate the sources ,
- Allow the environmental regulator access to records / premises,
- Keep adequate records including
  - date received,
  - activity on receipt,
  - manufacturers information,
  - a log book of use and location,
  - records of leak tests,
  - information on disposal or transfer if applicable
- Dispose of according to the conditions of the exemption (consult the Safety Office).

There is a requirement under EPR16 to demonstrate that Best Available Techniques are observed in order to minimise the disposal of radioactive waste to the environment and to minimise radiation exposures of the public. A section on Best Available Techniques (BAT) is included in the sealed source risk assessment format and this section must be completed.

Disposals of sealed sources may be made under exemption provisions as applicable, but the RPA must also be consulted.

Note that when purchasing a new source, the source manufacturer should recommend a working life for the source and after this time, the department should consider replacing the source or having it examined by the supplier or manufacturer. If not replaced, the condition of the source must be kept under review by departments (see also section 9.5).

Also refer to section 4.8 and 4.9 of the University Policy *Management of Work with Ionising Radiation* for further University requirements regarding control and keeping of radioactive substances.

4.3 Critical examinations

Installer's Duty

If there are radiation protection implications from installing, erecting, moving or modifying equipment containing a sealed source, a critical examination must be carried out and documentation sent to the Safety Office *prior* to work commencing.

A Radiation Protection Adviser must be consulted regarding the nature, extent and results of the critical examination.

The critical examination is to ensure that safety features and warning devices operate correctly and there is sufficient protection for persons from exposure to ionising radiation. The installer also has a responsibility to ensure sufficient user operating and maintenance instructions are provided. The installer should provide the department with evidence and information that the critical examination has been done and a record must be kept by the department. A copy of

the critical examination record should be sent by the department to the University RPA.

The employer who erects or installs the equipment is responsible for carrying out the critical examination. This would also apply in situations where moving or modifying the equipment may have safety implications. When constructing and commissioning equipment built "in house", the responsible employer is the University. When purchasing equipment installed by an external company, the installer is responsible.

Please check with the manufacturer or supplier prior to purchasing new equipment that a critical examination will be carried out on installation before use, and contact the Safety Office if there are any problems. If two or more employers are involved in the installation, it should be established prior to installation which employer is responsible for carrying out checks.

A copy of the certificate should be available to users of the equipment. A suggested critical examination checklist is shown in appendix 3, but this should be adapted if necessary. Further details on critical examination can be found in IRR17 regulation 32(2). Departments should take particular care to ensure that the critical examination process is followed for all relevant equipment.

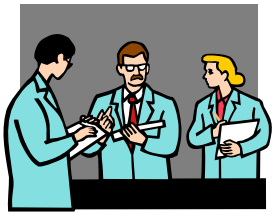
4.4 Authorisation to work

All users of sealed sources must be authorised to work by prior permission from their department, subject to training.

Users are registered to work by the local person responsible for the area, and a registration form, countersigned by the research supervisor and the RPS (if an RPS is appointed) must be completed for each user (appendix 5). The RPS will normally be the contact for new users, and the RPS may also be the person most appropriate to provide instruction in use and safe working practices involving the equipment.

For work where the risks are higher (for example work with an unshielded source) a limited time period "Permit to Work" system (signed by the RPS) should be used – again the decision, for a particular equipment or situation, to require a special permit system is a matter for RPA/RPS discussion. A decision whether to proceed with a special procedure must be made based on careful risk assessment and consultation with the RPS and RPA.

4.5 Training



All users will be required to attend suitable instruction and training for use of ionising radiations within the University.

Training must be appropriate to the work and the needs of the individual, and should be determined as part of the risk assessment process.

Training must include

- the risks to health from exposure to ionising radiation;
- any necessary precautions;
- the importance of complying with relevant requirements of the regulations (the general requirements summarised in this document and, where appropriate, additional specific requirements in "local rules" or written systems of work/procedures/instruction for specific work).

Appropriate practical in-lab training under supervision must be provided by the department and documented by the department. The Safety Office provides example induction checklists which departments can adapt as necessary. Before users are permitted to work unsupervised, they should be required by the RPS or person responsible for the equipment to demonstrate their knowledge by means of verbal or written tests/exercises as well as practical demonstrations.

The Safety Office does not provide regular sealed source training courses because applications of sealed sources are so varied across the University, although bespoke training is available on request. Please contact the Safety Office for further advice on suitable training for specific areas of work.

5 Designation of areas

The decision on appropriate designation of the area should be based on risk assessment and be made in consultation with the RPA. For sealed sources, the designation depends upon the accessible dose rates and the need for special procedures to restrict exposure, taking into account foreseeable accidents. In most cases, the physical control measures should be designed to sufficiently restrict exposure. However, if special procedures and instructions need to be followed *in addition* to the physical control measures, the area should be designated as a "c*ontrolled area"* and the procedures/instructions must be set out in a "System of Work" which can be incorporated into a local rules document. A "temporary controlled area" can be designated if appropriate.

Supervised areas are designated on the basis of keeping an area under review, or on the basis of accessible dose rates. Supervised areas are not normally appropriate for work with sealed sources.

6 Local Rules and the RPS

Local rules must be in place for all controlled areas (and some supervised areas). Where areas are neither controlled or supervised it may still be appropriate to have some written rules but these are not strictly "local rules" under IRR17.

Where local rules are in place, an RPS must be appointed. The role of the RPS is set out in section 2 of this document and in *Management of Work with Ionising Radiation.*

Local rules must include:

- details of the management and supervision of the work
- the name of the RPS
- the designation of the area and location/description of the designated area
- a summary of the working instructions and any special procedures necessary for restricting exposure (if controlled area)
- procedures for ensuring staff have received sufficient information, instruction and training
- contingency plans for any foreseeable accidents/incidents that might arise
- the University's formal dose investigation level as specified in section 4.2 of *Management of Work with Ionising Radiation*. For sealed source applications this is 2mSv whole body (effective) dose and 50mSv extremity dose.

For more information on local rules, refer to section 2.8 of *Management of Work with Ionising Radiation*.

7 Classified persons

Some radiation workers may be formally "classified" on the basis of possible significant exposures under the requirements of IRR17. However, this is not normally necessary for work with sealed sources in the University and the vast majority of radiation work is carried out by non-classified radiation workers. The RPA will advise on the process of classification if this is necessary.

8 Hazards and risks associated with sealed sources

8.1 *Biological effects of external exposure to ionising radiation*

Work with sealed sources can lead to *external* exposure of persons to radiation. The harm caused by exposure to ionising radiations may be manifest as early effects such as skin burns and late effects such as cancer and the risk of late effects is assumed to be proportional to the dose received. It is assumed that there is no threshold for the latter and so the emphasis is on avoiding unnecessary exposure in the first place and keeping any unavoidable exposure as low as reasonably practicable.

Dose limits are set out in Schedule 4, IRR17. It would never be acceptable for the type of work undertaken at the University to involve any person approaching these limits, although such a situation could occur in the event of an accident.

External exposure might arise from radioactive sealed sources outside or in contact with the body. The radiation dose rate depends on the radionuclide, the activity, exposure time, distance from the source and associated shielding (the Safety Office can provide data on request). It is in principle possible to predict doses from external radiation if the dose rate and time of exposure is estimated. Precise quantification of the dose and the risk is not always simple given that dose rates are typically highly localised and the exposure of the body is non-uniform. Sealed radioactive sources should not be manipulated directly by hand, unless risks have been assessed as insignificant.

As part of the risk assessment, estimates of the worst case dose rates give a useful

indication of the severity of harm (see table 1 below). Note that in an accident situation an assessment of the exposure is required under the regulations.

Table 1. External dose effects

Tissue	**Acute Dose (Gy) of gamma radiation**	**Effect**	**Latency**
Skin	2 Gy 6 Gy	Reddening Desquamation & Hair Loss	One day Ten days
Lens of Eye	0.5 Gy 5 Gy	Detectable lesions Cataract	Years Months
Ovary	2.5 Gy	Reduced Fertility	Days
Testis	0.15 Gy	Temporary sterility	Months
Bone Marrow	0.5 Gy	Reduced white cells	Days

Internal contamination is a possibility if the source is damaged allowing the dispersal of radioactive material. For this reason, sealed sources should, if practicable, be subject to regular, visible inspection, and must be leak tested every two years (section 9.5 and appendix 8 contain further information).

8.2 *Associated hazards*

Exposure to radiation is unlikely to be the only hazard associated with the work. Associated hazards include chemical, biological, electrical and other physical hazards. Research supervisors and others responsible for work areas and equipment must ensure that the risks from all associated hazards are assessed, and refer to separate risk assessments if necessary. Consult your Departmental Safety Officer and refer to the Safety Office website for more information on risk management and specific safety topics.

8.3 *Who is at risk?*

This will include the users and any co-workers but may also include others such as maintenance contractors, or workers in adjacent areas who may inadvertently be exposed to radiation. Particular consideration must be made of anyone who may be at particular risk, or for whom lower dose limits apply.

8.4 *Pregnancy and working with sealed sources*

Female employees are reminded that any work with ionising radiations presents a possible risk to the foetus. Although for most applications in the

University, the risk to both the mother and foetus will be very low, it is important that individuals notify the “employer” (preferably the department – the supervisor or line manager) in these situations so that the radiation risk assessment can be reviewed and a further risk assessment prepared if it is needed. Each case should be discussed with the Safety Office and the appropriate Radiation Protection Adviser. Notification can also be given, in confidence, via the University’s Occupational Health Service, who will seek advice from the Safety Office/Radiation Protection Advisers. Any recommendations on changes to work patterns are likely to be determined by the need to consider the risk of accidents since with normal procedures routine exposures should be negligible.

Further guidance on this and other general safety issues appears in the University's Maternity Policy. Also refer to section 4.3 of *Management of Work with Ionising Radiation*. A guidance leaflet is also available from the Health and Safety Executive website www.hse.gov.uk/pubns/indg334.pdf (appendix 7).

9 Practical control measures and precautions

This section sets out typical control measures and relevant information regarding requirements for maintenance and periodic checks of equipment. These standards of protection must be followed where possible, and the RPA must be consulted regarding any equipment which does not comply with these standards of control measures. Records of maintenance and checks on safety features should be kept in the form of a log book or similar document.

The practical control measures and precautions needed should be identified by prior risk assessment and the RPA must be consulted regarding significant new work.

Good design of facilities and engineering controls are essential to safe working with sealed sources. Purpose built equipment is normally designed and engineered so that it is safe for normal use. Equipment which is built in-house by a department, or used contrary to its intended use, or significantly modified will need to be carefully risk assessed and engineering and design controls applied as far as possible. The RPA must be consulted.

Administrative controls may complement design and engineering controls, but are only effective as long as they are followed and remain workable.

The use of personal protective equipment (PPE) is not normally relevant to work with sealed sources but PPE may be used for associated hazards (for example, for handling cryogens).

9.1 Storage and security of sources

Both IRR17 and EPR16 require that radioactive substances are kept and stored so that unauthorised access is not possible. The level of security should be reasonably practicable and proportional to the level of risk. Most significant sources are incorporated within equipment and access to both source and equipment should be controlled.

Minimum requirements are for all sealed sources to be stored in fireproof lockable containers within lockable rooms. For larger sources (GBq activities and above) additional security

measures may be required by the permit, and both the RPA and the University Security Office must be consulted.

9.2 *Accounting for sources*

When a new source is received full details of the source must be recorded in an appropriate register in the department. A copy of the source certificate (from the manufacturer/supplier) must be kept with the register, and a copy sent to the Safety Office. A record book must be kept detailing each date of use of the source, the users name and signature and a record of any leak tests and problems with the source or associated equipment or controls.

The regulations require that regular checks are made (accounting for sources) to ensure that sources are still where they are expected to be. Each individual piece of equipment containing a source should be made the responsibility of a named individual (RPS or other competent person). This nominated individual must be responsible for notifying the lead RPS in the department of any changes including proposed movement of the equipment and source. They must also ensure that there is a regular physical check made to confirm that the equipment containing the source AND the source itself is present. This may be done by a visual check of the source or source container, by using a suitable monitor, or by an operational check of the equipment to prove that the source is still present. RPA advice should be sought if it there is uncertainty as how to carry out the checks.

The frequency of checks must be justified by departments on the basis of risk assessment. For sources securely fastened within machines, a monthly check would be appropriate. For radiography and other “unattached” (portable) sources, a daily check should be made on sources. A record must be made and the records must be kept for at least two years, and for at least two years after a source is disposed of. The records must show:

- a means of identification (i.e. a unique ID which must also appear on the source or source holder)
- the date of receipt
- the activity at a specified date
- the whereabouts of the source, updated at regular intervals
- the date and manner of disposal (where appropriate).

9.3 *Handling sources*

Sealed sources should not be handled directly. As most sealed sources in use within the University are enclosed within equipment or within other shielding, this generally does not present a problem. If however, an unshielded source does need to be handled, the three basic principles of radiation protection must be considered in order to minimise exposure: time (minimise the time taken to carry out the process), distance (maximise the distance of any part of any person from the source) and shielding (i.e. can any temporary shielding be interspaced between individuals and the source during movement?). A risk assessment should be undertaken for all sealed radiation sources (see section 4.1) and particular care is needed if the skin of the hand is likely to receive a significant dose.

9.4 *Engineering and administrative controls (including shielding materials)*

For significant sealed sources enclosed within equipment, the design of safety systems will normally be the responsibility of the manufacturer. The manufacturer has a duty to provide information on safe use, maintenance of the equipment and any necessary checks on safety systems such as interlocks.

For some sealed source applications, enclosures or local shielding (as identified by risk assessment) may be designed and implemented by the department.

Materials used for shielding and enclosures

Shielding must be suitable for the radiation.

Alpha particles are very easily shielded – a single sheet of paper or the layer of skin on the outside of our bodies is sufficient (However, you should bear in mind that alpha emitters that are inhaled or ingested, for example Radon, are a significant hazard because the alpha particles can then be retained and cause damage inside the lungs or gut).

Beta particles are more penetrating than alpha particles and have a range of roughly 3 metres per MeV in air, or 3.5 mm per MeV in Perspex. Light materials such as Perspex and aluminium are a better choice than steel or lead for shielding beta particles. This is because heavier materials produce more Bremsstrahlung radiation (X-rays) than lighter materials, when they absorb beta particles.

Beta radiation therefore, is relatively easy to shield. As each beta source emits particles within a range of energies up to a known maximum, shielding can be constructed so that it will stop all of the beta particles, including the most energetic ones. A beta emitter with a maximum energy of 1.7 MeV will be completely stopped by 1cm of Perspex.

For shielding **gamma rays**, heavy materials such as lead, steel or concrete are normally used. For a single radiation energy, the attenuation follows an exponential law, so that a fixed thickness of the shielding material will only reduce the incoming radiation by a fixed amount.

This gives rise to tables of “half value thickness” and “tenth value thickness” as a convenient way of calculating the shielding required for a given application

Half and tenth value thickness for lead:

Source	Half value thickness for lead in mm	Tenth value thickness for lead in mm
Caesium 137	6.5	22
Cobalt 60	11	40

Shielding for **neutrons** is achieved by application of attenuating materials with a high hydrogen content (for example, water). Concrete or paraffin (liquids/solids) can also be employed – several meters of shielding may be needed. If gamma radiation is also

present, a gamma attenuator, such as lead, will be required between the source and the neutron attenuating material.

If you require specific advice for particular applications, this should be discussed with the departmental RPS (if an RPS is appointed), and contact the RPA at the University Safety Office.

Safe working procedures

Clear and concise instructions for safe use of equipment should be summarised in rules, local rules, and/or a system of work as appropriate (see section 6) and must be readily available to users.

Warning signs

It is a requirement of EPR16 that in areas where radioactive materials including sealed sources are kept and used, the radiation trefoil should be displayed along with the words “Radioactive” materials or substances. Appropriate warning signs should also be in place depending on the designation of the area. Suggested signs are available on the Safety Office website which departments can amend as necessary, laminate and display http://www.admin.cam.ac.uk/cam-only/offices/safety/radiation/ir/forms/

Any radiation warning notices displayed in the working area should always be followed; these notices are part of local rules. Consider who might be affected by the work and ensure that they understand the meaning of any warning signs.

9.5 *Leak Testing*

Sealed sources are designed so that the radioactivity is well contained. However, over time or in the event of misuse or damage of a source, the contained substance may leak and create potentially serious contamination.

IRR17 requires (Regulation 28) that, where appropriate, suitable leak tests are carried out for sealed sources and the interval between tests should not normally exceed two years.

Proof of leak tests should be provided on purchase and the source manufacturer may advise on periodic leak tests and methods.

For further information on leak testing, please refer to the University Safety Office publication, *Leak Testing of Radioactive Sealed Sources*.

Tests are not usually considered appropriate in the following circumstances (although care is always needed to prevent contamination):

- sealed sources which contain solely gaseous radioactive substances
- smoke detectors
- sources or articles which have no dimensions greater than 5 mm, for example gold grains and microspheres. These may be treated as dispersible radioactive

substances (however, this advice is not intended to preclude leak tests being carried out on smaller sources where it is appropriate).

Increasing the frequency of leak testing is advisable when a sealed source is going to be retained in use beyond the recommended working life given to the source capsule by the supplier or manufacturer. Where there is no recommended working life, then the frequency of leak testing needs to be considered as part of the periodic reviews of its condition.

Records of leak tests:

The recommended contents of a suitable leak test record are:

a) the identification of the source or article which is the subject of the test

b) the date of test

c) the reason for test (e.g. pre-use, manufacturer's test, nominal routine, after incident)

d) the methods of test, including, when the source or article has not been tested directly, a statement of what part of the device was tested and a statement about whether this is likely to detect any leaking material. The description of the test will normally include a statement of the pass/fail criteria.

e) numerical results of the test

f) the conclusion of the test (pass or fail)

g) any action taken if the source failed the test

h) the name and signature of the person carrying out the test.

9.6 *Personal and Environmental Monitoring*

In undertaking work with ionising radiation, the University must ensure that employees and other persons are not exposed to ionising radiations to an extent that statutory dose limits are exceeded. This sort of exposure is unlikely bearing in mind the sort of work undertaken at the University. However ALL doses must be kept as low as reasonably practicable, and personal and environmental monitoring is carried out, in order to demonstrate ALARP.

The risk assessment process should indicate the requirements for monitoring, both personal (film badge or TLD) and environmental, for example, monitoring a piece of equipment for radiation leakage.

The requirements for monitoring – both environmental and personal, must be set down in local rules and any systems of work/written arrangements. Environmental monitoring may include the use of some "personal dosimetry" (see below) used to monitor an "area" rather than an individual, by positioning in a room in which an enclosed source is present. This type of area monitoring may have some use, for instance for "re-assurance" purposes, when gaining experience with new or modified equipment, but generally has been found to be of little real value if continued for long periods – direct monitoring using an appropriate hand held radiation monitor is far more effective.

The results of any monitoring should confirm that control measures are appropriate,

therefore monitoring is part of the risk assessment review process.

Personal monitoring

Personal monitoring is carried out using film or TLD badges for whole body monitoring, or thermo-luminescent dosemeter (TLD) rings for extremity monitoring. These will be issued depending on the outcome of risk assessments, and retrospective dose reports are provided, with a minimum reporting level. Any unusual results or exposures will be discussed with the users involved. The Safety Office and RPA will undertake a formal investigation if, in any year, whole body monitoring of an individual indicates an accumulated effective (whole body) dose of 2mSv, or an extremity dose of 50mSv.

Consultation with the RPA, along with a properly carried out risk assessment (section 4.1 and appendix 2 of this document) will indicate the requirements for personal dose monitoring.

If dosimetry is issued, it must be worn for all work with ionising radiation, looked after and returned on a monthly basis according to arrangements set up by the department and the Safety Office. There are legal duties placed on employees to care for and return dosimetry promptly for assessment.

Finger extremity monitors should be worn on the appropriate hand, with the detecting surface towards the source of radiation.

Whole body badges should be worn on the outside of clothing.

Never leave films or extremity monitors close to radiation sources, and also ensure that badges are removed from protective clothing before sending it to the laundry.

Environmental monitoring

Environmental monitoring is carried out as part of the legal obligation on an employer to ensure that control measures are effective. The regulations (IRR) also specify equipment requirements for annual test and record keeping.

Environmental monitoring applicable to sealed sources includes dose rate measurements and leak checks. If you wish to purchase a monitor, please contact the RPA who will advise on a suitable monitor (also refer to appendix 4).

Dose rate monitors are relatively expensive, and this type of monitoring can be done during visits from the Safety Office. Dose rate measurements should always be done when new techniques or equipment are introduced into a department, and may inform or verify the risk assessment process.

Annual test of monitors is arranged by the Safety Office. Please check that all departmental monitors are tested each year (a label on the monitor indicates due date of next test), and contact the Safety Office if there are any problems.

9.7 *Personal protective equipment (PPE)*

PPE is not normally relevant to work with sealed sources but if it is used regular checks must be made on the condition of such equipment.

10 Contingency plans

In the event of any incident, accident, fault or suspected fault involving a sealed source, the contingency plans will depend on the risk assessment. Contingency plans must be set out in local rules or other rules and procedures. The RPS must be informed. If the matter is an incident which has resulted from failure of safety devices, and/or resulted in exposure of persons to ionising radiation, then the RPA must immediately be informed.

It may not be practicable to *rehearse* the arrangements for contingency plans for sealed sources but the Ionising Radiations Regulations require that "where appropriate" the arrangements in such plans are rehearsed. All users must be fully aware of the plans and must know their role, and who to contact in the event of untoward events. The availability of equipment (monitors), personnel and advice, to deal with situations should be regularly checked by the (senior) RPS, and a written record made**.**

11 Reporting Incidents

All significant accidents and incidents should be reported to the departmental RPS and the RPA at the Safety Office as soon as possible after the event to ensure appropriate follow up and medical supervision or reassurance to the individual. Some incidents also require reporting to the regulators. Departments should submit an accident report via the Departmental Safety Officer. Accidents that are significant and must be reported are:

1. failure of equipment containing a sealed source to terminate the exposure by the usual means, such as failure to return the source to safe position
2. failure of an interlock or other safety device which causes or has the potential to cause an exposure
3. any suspected overexposure for any reason
4. damage to a source, theft or loss. Check with the RPA any additional requirements to report under IRR17, the conditions of an EPR permit or exemption provisions.

In these situations the RPS will discuss the situation with the University RPA. Any notifications of the regulators will be done through the Safety Office.

12 Further information and advice on specific sealed source applications

The applications listed below refer to various sealed sources currently used within the University. For specific advice on anything not covered below, please contact the Safety Office. Please refer to section 9.2 for specific advice on keeping track of sources, including identifying a named individual to ensure regular checks.

12.1 *Irradiators*

Irradiators are shielded equipment containing one or more sealed sources used for delivering generally very high radiation doses to samples. Examples are Caesium-137 irradiators used in medical and biological research departments. These contain tens of TeraBecquerels of activity and are held under an EPR permit. A usage log-book must be kept with the machine or with the key holder. Regular recorded checks must be made to confirm the source remains in place within the irradiator. This can be done by monitoring at a known point on the surface of the shielding. Generally, all irradiators will have areas of very slight elevated background, so this characteristic can be used to "confirm" the presence of the source. Annual "leak tests" to determine the integrity of the source must be carried out (at least every two years) – obviously due to the high activity of the sources, the source itself cannot be wiped, so the nearest accessible surface to the source transport route should be wipe tested. This test can most conveniently be performed at the time of an annual service by the supplier, manufacturer or another competent body.

The security issues associated with large sealed sources in general and specifically irradiators, has become a high priority for the Environment Agency when inspecting facilities housing these sources. The EA expect close supervision and control, secure rooms to house the equipment, including recorded swipe card type access, and, often, some type of CCTV or PIR surveillance equipment. These arrangements will be in place for existing irradiators in the University, but it is essential that any plans to buy or install any additional irradiators within University departments, is brought to the attention of the Safety Office/RPA as soon as possible.

12.2 *Alpha ionisation devices*

This includes static elimination devices containing alpha emitting sources in which the alpha particles are used to neutralise positive and negative static charges. A permit is normally required for keeping and using these sources under EPR16.

Another type of alpha ionisation device is a smoke detector which includes a small Americium-241 source, producing ionisation and a small, constant current between two electrodes. If smoke is present, this interrupts the current and sets off the alarm. Smoke detectors are held and used under exemption provisions but some limits apply on activity and also, if not fixed to the premises, on the number of detectors held. Departments should not accumulate stocks of smoke detectors (whether they are usable detectors or waste). Smoke detectors containing less than 40kBq of

Americium-241 can be disposed of, one per week, to normal dustbin waste. For disposal of any higher activity smoke detector sources, please contact the Safety Office for advice.

12.3 *Electron Capture devices*

These are beta radiation sources which are used in gas chromatography. Typical sources are Nickel-63 and less commonly, Tritium. These sources need to be leak tested carefully as they can easily be damaged – advice and leak test kits should be available from the source supplier. These sources are normally held under the exemption provisions under EPR. Although exempt from the need for a permit under EPR16, the exemption requirements apply to these small sealed sources (see section 4.2 for exemption provisions and section 9.2 for specific advice on keeping track of sources, including identifying a named individual to ensure regular checks.)

12.4 *Moisture density gauges, neutron probes*

A guidance leaflet is available from the Health and Safety Executive http://www.hse.gov.uk/pubns/iris3.pdf (IRIS Sheet No 3, August 2002).

These gauges normally contain a large Americium-241 source, and some contain a Caesium-137 source. Both gamma and neutron radiation may be emitted from the devices. The sources contained within these gauges fall within the full requirements of permitting under EPR16 and IRR17.

It is therefore essential that the University holds a permit to use these sources under EPR16, and that risk assessments and local rules are prepared **before** such equipment is purchased or used. The Safety Office/RPA MUST be consulted regarding any new or changed work involving such gauges. Work with them is likely to involve setting up temporary controlled areas, and special arrangements for personal neutron monitoring are likely to be advised for those carrying out the work. Transport Regulations will apply when getting the sources to the location where they are to be used (consult the Safety Office/RPA).

12.5 *Liquid scintillation/ gamma counters*

These contain small gamma sources embedded within the counter that are used to calibrate the equipment. The sources are normally held under the exemption provisions under EPR and departments must be aware of the requirements. Although exempt from the need for a permit under EPR16 the exemption requirements apply to these small sealed sources (see section 4.2).

Please refer to section 9.2 for specific advice on keeping track of sources, including identifying a named individual to ensure regular checks. Source checks can be made by using a suitable monitor (if the source can be easily detected) or by carrying out an operational check of the equipment to prove that the source is still present (for example, an efficiency correction on a scintillation counter).

The counter should be clearly labelled as containing a radioactive source and the department must ensure that such sources are not disposed of along with the

This equipment contains a radioactive source.

Do NOT dispose without permission of the RPA, University Safety Office

equipment. The manufacturer should provide labelling, but, as this label is normally out of sight on the back of the counter, departments should fix an additional label on the front of the equipment (see the above example). Contact the Safety Office/RPA prior to disposal or removal.

Note that leak testing not considered practicable as the source is embedded and the source housing is not easily accessible to wipe.

12.6 *Classroom/ teaching sources*

The CLEAPPS guidance, *Managing Ionising Radiations and Radioactive Substances in Schools, etc L93,* http://science.cleapss.org.uk/resource/L093-Managing-Ionising-Radiations-and-Radioactive-Substances-in-Schools-and-Colleges.pdf contains useful guidance and example risk assessments for typical teaching sources, but note that some of the advice on disposal may only apply to schools rather than Universities so consult the Safety Office/RPA.

Larger sources may require a permit under EPR16 but small sources are normally held under the exemption provisions under EPR. Although exempt from the need for a permit under EPR16, the exemption requirements apply to these small sealed sources (see section 4.2 for exemption provisions and section 9.2 for specific advice on keeping track of sources, including identifying a named individual to ensure regular checks.)