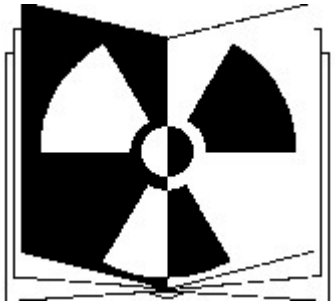

Association of University Radiation Protection Officers

AURPO Guidance Notes on Working with Ionising Radiations in Research and Teaching

March 2002 Edition

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FOREWORD

This document has been produced as an aid to Radiation Protection Officers and others with responsibilities for radiation protection in a University or biomedical research environment. The document therefore emphasises the normal roles and duties of these employees as it is important that everyone is aware of their own individual responsibilities. However, in most circumstances employees will only be assisting their employer to comply with the requirements of the Ionising Radiations Regulations and it is the radiation employer who has the legal responsibility for compliance and this responsibility can not be delegated. It is important that senior management are made aware of their responsibility.

The formal dose limits in the regulations are rarely of relevance in a university/small user context. Most organisations should find that worker doses can be kept well below even the general public limits. Of principle concern in our sector should be the restriction of exposure and keeping doses as low as reasonably practicable (ALARP). This should be foremost in the minds of those people implementing this guidance.

We have tried to keep this guidance concise and direct; repetition of regulations and guidance given in the Approved Code of Practice has therefore been avoided wherever possible. Whilst this document can stand alone, those with responsibilities for implementing the requirements of the regulations are recommended to have copies of the Ionising Radiations Regulations 1999 and the Approved Code of Practice and Guidance for reference. Details of the appropriate regulations and paragraphs along with other useful references and additional explanations are given in the left-hand column.

It is hoped that you find this document of practical assistance in fulfilling the requirements of the regulations. It is intended to review and update the document on a regular basis and to publish it on the AURPO Website at :-

http://www.shef.ac.uk/~aurpo/publns.html

This will give members the opportunity to request additional guidance and to suggest inputs for the further development of this document.

T.J.Moseley

CONTENTS

Section	Page	Para
Getting Started	**1**	**1**
Management of Radiation Protection	**2**	**10**
Risk Assessments	**6**	**36**
Restriction of Exposure	**9**	**49**
Designation and Monitoring of Areas	**12**	**71**
Dose Limitation, Classification and Monitoring of Persons	**15**	**91**
Control of Radioactive Substances, Articles and Equipment	**20**	**128**

Appendices

Appendix 1 - Protection from the External Hazard	**25**
Appendix 2 - Decontamination Procedures	**27**
Appendix 3 - Models for Designating Areas	**29**
Appendix 4 - Laboratory Design	**34**
(including Environment Agency Guidance)	
Appendix 5 - Examples of Training Records	**41**
Appendix 6 - Example of Wipe Test for Tritium	**45**
Appendix 7 - Table of Common Radionuclides	**46**
Appendix 8 - Biological Monitoring	**47**
Appendix 9 - Radiological Compliance Audit Check-List	**48**
Appendix 10 - Surface Contamination Action Levels	**51**
Appendix 11 - Record Keeping	**54**
Appendix 12 - Glossary of Terms	**55**
Appendix 13 - References	**56**

Getting Started

Justifying Work Practices

1. It is important that all work with ionising radiations can be justified. Alternatives to the use of ionising radiations must always be considered and the risks and benefits assessed.

No current legislation covers justification, but it is envisaged that all current uses in university research and teaching and biomedical research and development should meet future guidelines.

Authorisation of Practices

Radioactive Substances Act 1993 (RSA93) (*Ref A1*)

2. All Establishments where work is undertaken with sealed or unsealed sources must obtain one or more Certificates of Registration from the Environment Agency, or their regional equivalent, prior to commencing such work. Establishments undertaking work with unsealed sources will also require a Certificate of Authorisation, from the same Agency, permitting the accumulation and disposal of radioactive waste.

3. Schools may be covered by Exemption Orders in certain circumstances for work involving ionising radiations. Guidance on this will be given when available.

IRR99- Reg 5 (*Ref A2*)

Authorisation of specified practices

4. Where work involves the use of x-ray equipment, neutron generators and accelerators then there is a requirement for prior authorisation. Some practices will be exempt: use of electron microscopes; diagnostic use of x-rays in medical and veterinary practice; use of x-rays for routine analytical, diagnostic or investigative purposes; use of x-rays in baggage, postal or food screening and the use of x-ray gauging and detection systems in measurement processes. For other practices, generic authorisations provided by the HSE should cover all routine work. If the radiation employer can satisfy the conditions of the appropriate generic authorisation then the employer does not need to apply to the HSE for an authorisation. It is envisaged that most people will be able to meet the relevant conditions.

See HSE information sheet -

Guidance Relating to Prior Authorisations. (*Ref A4*)

Notification of Work with Ionising Radiations

IRR 85 - Reg 5 (*Ref A5*)

5. The HSE should have been informed of all premises used for existing work with ionising radiations and the type of work undertaken under the requirements of the Ionising Radiations Regulations 1985. No new notification is required for this.

IRR 99 -Reg 6

Notification of specified work

6. Where, however, an establishment proposes to work with ionising radiations, **for the first time**, at least 28 days notice must be given to the HSE before commencing the work. If the establishment has previously notified the HSE of its work with ionising radiations but proposes to occupy new premises or alter the nature of the work, then these changes must also be notified to the HSE before introduction of the changes. (This does not apply to new buildings on an existing registered site.)

7. There are exemptions to notification, the main ones being:

(i) where only small quantities of radioactive material are used; and

(ii) where work involves the use of equipment approved by the HSE which incorporates either radiation generators or sealed sources where dose-rates do not exceed 1microsievert h^{-1} at a distance of 0.1m from any accessible surface.

IRR 99 - Schedule 1

Work not required to be notified

(see also Schedule 8) and Appendix 7

It is expected that only limited use of these exemptions will be made in most Establishments.

8. Where work with ionising radiations has ceased and the radiation employer is planning to vacate the premises then there is a duty to inform the HSE of the cessation of work.

9. Where work with radioactive materials has ceased then there is also a duty to inform the Environment Agency. Before the Environment Agency will cancel certificates of waste authorisation and registration of open sources they will need to be assured that no radioactive material remains on the premises and that no part of the premises, or site, remains contaminated.

Notification under Reg 6(6)

Cessation of work

Revocations of certificates of

registration and authorisation
under RSA93

(guidance available from EA-currently in draft form - Ref E6)

Management of Radiation Protection

Management Structure

Managerial Responsibility Advisory/Supervisory Role

Vice-Chancellor Radiation Safety/Health and Safety Committee

See - CVCP Code of Practice for University Health and Safety Management (*Ref E1*)

(Chief Executive Officer) (Senior Health & Safety Management)

This simplified flow chart shows lines of responsibility (solid lines)

Radiation Protection Officer/Adviser

and advisory/supervisory roles (dotted lines)

Head of Department

Academic Supervisors Departmental Radiation Protection Supervisors

(Section Supervisors)

Radiation Workers

10. In some establishments the titles people are given may be different. Also the Radiation Protection Officer/Adviser and Radiation Protection Supervisors may have managerial functions and responsibilities as well as fulfilling advisory/supervisory roles. It should be noted that the roles of Radiation Protection Adviser (RPA) and Radiation Protection Supervisor (RPS) are statutory requirements defined in IRR99. The post of Radiation Protection Officer (RPO) is not an IRR99 requirement and the appointment of such a person is at the discretion of the establishment's management.

Introduction

11. To ensure that all relevant regulations governing work with ionising radiations are observed throughout the establishment there should be a clearly defined chain of responsibility and all personnel involved at every level must be made fully aware of their individual responsibilities to themselves and others. In particular, managers and department heads have a direct responsibility for the day-to-day health, safety and welfare of all those at work in their area. They are responsible for ensuring ,

both by example and by direct management intervention, that all safety and environmental procedures are complied with.

12. The establishment may have established either a separate Radiation Safety Committee or made this one of the remits of the Health and Safety Committee. (NB There is no legal requirement for a Radiation Safety Committee.) The Committee should receive reports from the establishment's Radiation Protection Officer and advise the senior management on any actions that need to be taken.

The Safety Representatives and Safety Committees Regs 1977

(*Ref A16*)

Health and Safety (Consultation with Employees) Regulations 1996 (*Ref A17*)

Vice-Chancellor/Chief Executive Officer

13. Vice-Chancellors or Chief Executive Officers have overall responsibility for radiation safety and all health and safety matters. One of the things that they must ensure is that they have in place a health and safety policy which covers all aspects of work with ionising radiations and covers all those people affected by or involved in research, teaching or other work activities.

Head of Department

14. Heads of Department are directly responsible to the governing body/ senior management of the establishment for all work undertaken by staff and students within their department. As a representative of the employer they must have a management system in place within their department that ensures that all the requirements of IRR99 and RSA93 are fully met.

Radiation Protection Officer/Adviser

15. All establishments are recommended to employ a suitably qualified and experienced person to act as a Radiation Protection Officer (RPO), often also named as a Radiation Safety Officer (RSO), in either a part-time or full-time post. They will be responsible, on behalf of the employer, for ensuring that the requirements of the Ionising Radiations Regulations 1999 are met. It should be noted however that under the regulations the legal responsibility to ensure compliance remains with the employer. The RPO may also be expected to act as the establishment's 'Competent Person', as required by the Certificates of Registration and Authorisation issued under the Radioactive Substances Act 1993.

16. An establishment should consult with a Radiation Protection Adviser (RPA) prior to undertaking any work with ionising radiations. If it is found that the work with ionising radiations requires the setting up of 'Controlled' or 'Supervised ' areas, or, uses equipment that without the engineering controls and design features incorporated would require the setting up of such areas, then it will need to appoint a RPA. In some circumstances this may be the same person as the RPO but it could be an outside appointee, a corporate body acting as RPA, or an internal appointment (e.g. a senior academic whose role is purely advisory). Having appointed a RPA it is important that the employer is aware of their responsibility to consult the RPA on all the matters specified in the regulations and ACOP.

IRR 99: Reg 13 and Schedule 5

- appointment of RPA

regulations and ACOP.

See ACOP paras 216 - 233

(*Ref A3*)

17. In appointing a RPA the establishment must ensure that the individual so appointed is suitably qualified and experienced to advise on all aspects of ionising radiations that are relevant. Competence can be demonstrated by the appointee holding a relevant certificate of competence issued by a professional body or a relevant National/Scottish Vocational Qualification (N/SVQ).

18. Certificates of competence are normally valid for 5 years and holders must keep up to date and be able to demonstrate continued competence to obtain renewal.

See - RPA 2000 (*Ref E2*)

RPAs who are already in post and whose appointment has been notified to the HSE are exempt from this requirement until 31.12.2004.

Radiation Protection Supervisors (RPS)

IRR 99 Reg 17(4)

- appointment of radiation protection supervisors

See - HSE Information Sheet on Radiation Protection Supervisors

(*Ref A7*)

The HSE have suggested a ratio of approximately 20:1 will provide suitable levels of supervision in a typical university department.

19. Normally, the Head of every Department working with ionising radiations, should, in consultation with the RPA, appoint one or more RPSs from suitably qualified, trained and experienced members of staff to oversee the work. The need for more than one RPS in a department will depend upon: the extent and degree of complexity of the work undertaken; the number of controlled and supervised areas and their geographical distribution; and, the number of people working in such areas. For example: in a department where both x-rays and unsealed sources are used, it is unlikely that any one staff member will have an expertise in both fields, so a separate RPS would be required for each field. In large departments with a number of controlled areas or separate store/dispensaries, it may be appropriate to have a RPS responsible for each of such areas.

20. It will be the role of the RPS to monitor compliance with the 'Local Rules' in order to meet the requirements of IRR99. It should be noted that the legal responsibility under the regulations to ensure compliance remains with the employer. The employer may also require the RPS to fulfil other radiation safety responsibilities over and above those required by IRR99. These are undertaken in their management role and not as RPS under IRR99. RPSs may devote only part of their time to radiation protection work and they may not exercise direct supervision of the work themselves as this is a duty of the academic/ section supervisor. In some establishments it may be appropriate to appoint the section supervisor as a RPS.

‘Non-designated work’ means work in areas that do not require

21. In departments engaged only in non-designated work, the

designation as controlled or supervised areas.

appointment of a RPS is discretional and the Head of Department may use the Departmental Safety Officer or him/herself to oversee the work. Managerial control of the work will still be required.

Academic/Section Supervisor

See - ESAC - Managing health and safety aspects of research in higher and further education p5 - The supervisor's role (*ref E15*)

22. The departmental RPS cannot be expected to supervise directly all the work with ionising radiations, and here the academic/section supervisors play an important role. Academic/section supervisors will need to ensure, as part of their role and management function, that the people working under their supervision receive the necessary training and instruction to enable them to work in a safe manner and in accordance with the local rules. Academic/section supervisors themselves should have received adequate training and clearly understand their management role in the organisation.

23. Academic/section supervisors must supervise closely those working under them until the individuals concerned can show that they are capable of working independently and responsibly with ionising radiations.

NB There is still a responsibility to supervise radiation workers by a regular monitoring of their activities even after they have demonstrated competence.

Radiation Worker

IRR 99 - Reg 34

- duties of employees

24. Before starting work with ionising radiations, radiation workers should, familiarise themselves with: all pertinent local rules; the physical, chemical and biological properties of the radioactive material, or physical properties of other ionising radiations which they propose to use; and the precautions that need to be taken. This should be an integral part of their training.

Radiation workers have a legal responsibility to protect both themselves and others from any hazard arising from their work, and they must not expose themselves or others to ionising radiations to a greater extent than is reasonably necessary for the purpose of their work. In this respect, they should be instructed to make full and proper use of all protective equipment provided for their safety and to report any defects they find in such equipment.

Provision of information, instruction and training

IRR 99 - Reg 14 Information instruction and training

25. All personnel involved in work with ionising radiations must be adequately trained and the training should be tailored to reflect the type and complexity of the work they will be undertaking.

26. Although the overall responsibility of the employer, training may be at two levels: that organised centrally by the RPO/RPA and that organised at departmental level.

AURPO Guidance Note No.5

Notes for Training of Radiation Workers in Universities (*Ref D2*)

IAEA Safety Report Series No.20

27. Core training should cover a basic introduction to radiation protection, legal and administrative requirements and practical training in restriction of exposure related to the general type of work in which they are involved. This could be of a minimum duration of a couple of hours or up to 2 days depending on how much of the training is devolved to the departmental level and the level and complexity of the work involved e.g. the legal aspects of work with x-rays are much more

Training in Radiation Protection and the Safe Use of Radiation Sources (*Ref C10*)

straightforward than the host of rules and regulations governing work with unsealed sources.

28. Training at departmental level could be provided by the RPS and the appropriate academic/section supervisor. Radiation workers will need to be instructed in the specific techniques with which they will be concerned and the departmental procedures with which they will need to be familiar e.g. ordering and storage of radionuclides, waste disposal.

29. Management should satisfy itself of the competence of individuals before allowing them to work with ionising radiations.

Records of Training

See - Appendix 5

Example of training records

30. It is important that records are kept of training given both centrally and at departmental level. A certificate may be issued so that if workers transfer to another establishment they can produce proof of training. This certificate in itself however will not constitute evidence that the individual is sufficiently trained for work in a new establishment.

Local Rules and other information

IRR 99 - Reg 17(1)

31. Local Rules in the context of IRR99 are a legal requirement for controlled and, where appropriate, supervised areas. They are normally produced on behalf of the employer by either the RPO or such other person delegated to do this task. The RPA should be consulted as to their content.

See ACOP para 272 – 288

(*Ref A3)*

32. Although not a legal requirement, reference to local rules in these guidance notes covers all radiation areas. Local rules should reflect good practice, should be designed to be easily followed and ensure that all exposures to ionising radiations are kept as low as reasonably practicable. The degree of detail required in the local rules should reflect the radiological risk and the nature of the operations undertaken.

33. Radiation workers should be informed and instructed about all local rules relevant to their work and asked to confirm that they have read and understood them. It is important that local rules are clear and concise and focus the radiation workers' attention on their responsibilities. Additional guidance notes may be provided for reference.

IRR 99 - Reg 15

Co-operation between employers

See paras 116-118 for further guidance on visitors and outside workers.

34. In higher educational establishments, research establishments and hospitals there are numerous occasions when staff from one Establishment will work in another. The employers have a duty to co-operate and exchange information on all risks and arrangements and it is important that the Radiation Protection Officers are kept informed of any arrangements that are made. As a general rule personal dose-meters should be used only at the issuing employers premises unless individuals are involved in peripatetic work.

See IRR99 Reg 15, Reg 18(4), Reg 21(2)

See IRR99 Reg 21(5)

35. The radiation employer should establish the previous radiation status of all radiation workers, and, if necessary, exchange information on radiation exposures and potential exposures. People working in another

employer's controlled areas may need to be registered as outside workers and require the issuing of passbooks.

Risk Assessments

General

Management of Health and Safety at Work Regs - Reg 3

(*Ref A8)*

IRR 99 - Reg 7

See ACOP paras 36 - 55

(*Ref A3*)

36. Before commencing a new work activity involving ionising radiations the employer has a responsibility to ensure that a risk assessment is made which identifies the hazards and evaluates the nature and magnitude of the risks to which both workers and members of the general public could be subjected.

37. It should be normal practice in all establishments for all new work activities to be registered with the employer and assessed (normally a function of the RPO). These procedures should be reviewed to ensure that they meet the requirements for risk assessments as detailed in the Management Regulations.

* Some Establishments require all work to be registered centrally and issue 'work certificates', others may have alternative arrangements for ensuring control of ionising radiations.

38. The risk assessment could be made as part of the work registration procedure* by a competent person on behalf of the employer. This may be the RPO, RPS or local supervisor depending upon individual circumstances. For the purposes of this document we shall call the person making the risk assessment the 'Assessor'. It is important to identify significant risks and the time, effort and detail of a risk assessment should be proportionate to the perceived risk and action required. Activities handled, estimated dose-rates and the likelihood of contamination are all factors that will determine the designation of the area and this in itself will act as a guide in assessing the magnitude of the risks. For example, in work involving unsealed sources, if it can be clearly demonstrated, by use of NRPB-M443, that likely worker doses are extremely low, then there is little more to be done other than detailing standard working procedures for that type of work. In many cases simple generic assessments will be acceptable, as long as they can be shown to be suitable and sufficient, but some may wish to involve the individual researcher in this process as a means of monitoring their competence in radiation safety.

See Appendix 3 Model A

and NRPB-M443 *(Ref E3)*

39. Given the precautions already taken to practice ALARP and the record of minimal radiation doses in research and teaching, the residual risks in most activities will be very small and the conclusions of the risk assessments should reflect this. There should therefore be little requirement for further action over and above the standard procedures currently advised.

See 'Restriction of Exposure' starting page 9

40. Different types of activity will involve different hazards and risks and therefore it is worthwhile considering them separately.

Risk Assessments for work involving unsealed sources

41. The Assessor should be familiar with the properties of all the radionuclides, that it is intended to use. The following are some of the other items which will need to be considered:-

- could sealed sources be used for this application?
- the quantities handled and the frequency of procedures
- the degree of any external hazard
- the degree of any air contamination hazard
- manufacturer's guidance relating to storage, dispensing and handling of the material
- the risks associated with different waste streams
- the grading and suitability of laboratory facilities
- the effectiveness of general procedures taken to restrict exposure i.e. shielding, containment, monitoring, protective clothing

Risk Assessments for work involving sealed sources

42. The Assessor should be familiar with the sources to be used and the dose-rates associated with them. Normally, high activity sources should be housed in purpose built equipment or facilities such that the dose-rate to which a worker would normally be exposed would be less than 7.5 microsievert h^{-1} and usually less than 2.5 microsievert h^{-1} if reasonably practicable. The Assessor will need to carry out a survey to establish that the dose-rates outside the equipment/facility are satisfactory.

43. Only those personnel involved in source changing are likely to be subjected to higher dose-rates and possibly a significant risk of exposure. The risk assessment should therefore concentrate on the operations, which those personnel perform and an estimate of dose/operation should be recorded. (This may not be necessary if this work is contracted to a third party.)

See also paras 34-35, co-operation between employers

Risk Assessments involving machine sources.

IRR99 Reg 31

ACOP paras 518 - 526

See also paras 158-159, duties on manufacturers.

44. When equipment is first installed it is the responsibility of the installer to ensure that a critical examination is undertaken. This should ensure that all safety features and warning indicators are functioning correctly and that dose-rates associated with use of the equipment are within design specifications so that adequate protection is provided from ionising radiations for both staff and members of the public. The RPO/RPA, on behalf of the employer, should be consulted about the nature of the critical examination. The RPO/RPA may wish to carry out a confirmatory survey and may need to check that shielding, incorporated into the building fabric, is performing to expectations. A survey will also need to be carried out

whenever a machine is relocated.

45. With X-ray crystallographic equipment there may be alignment procedures which require over-riding of some of the standard design safety features. These procedures should be restricted to named authorised personnel and carefully assessed. If practicable additional mechanical items/engineering controls should be used for these procedures to minimise potential radiation dose. Where it is considered necessary to set up a controlled area during alignment, then specific written procedures will be required.

See - A Guide to Radiation Protection in the Use of X-Ray Optics Equipment

(*Ref D4*)

Risk Assessments and Emergency Procedures

46. An important part of the risk assessment is to evaluate accident scenarios and consider the actions to be taken in emergency situations. Every laboratory should have at least simple emergency action plans with key information posted in the laboratory. All radiation workers should be made aware of the action to be taken in the event of an emergency.

47. Where the work involves the use of controlled areas and a radiation accident is reasonably foreseeable (e.g. fire, spillages), then a more detailed contingency plan will be required. The contingency plan will need to be incorporated into the 'local rules'. Those employees affected will need to receive appropriate training in implementation of the contingency plan and rehearsals of the arrangements in the plan should be carried out as deemed necessary by the RPA.

IRR99 Reg 12

Recording the results of the Risk Assessments

48. All risk assessments should be recorded but this does not mean duplication of existing procedures. It should already be standard practice to draw up guidelines in the form of: a protocol; working instructions; work certificate or local rules for each project or use of a particular item of equipment. These guidelines should reflect the results of the risk assessment, detailing action necessary to reduce exposure, and form evidence of a risk assessment being undertaken. They may need only minor modification to meet current regulatory requirements. All risk assessments should also be reviewed periodically and the results of such reviews recorded.

Restriction of Exposure

General

IRR 99 - Reg 8

49. The employer should use all reasonably practicable means to restrict exposure to ionising radiations to low levels. For most types of work activity undertaken it has been established that the average radiation dose

See also ACOP paras 59 - 162

See ICRP 60 para S21 *(Ref C1)*

See NRPB-R311 *(Ref E14)*

to university radiation workers is extremely low, with the average in 1996 being 0.03mSv/annum. It should be reasonably practicable therefore to keep all doses well below even the general public limits, i.e. 1mSv/annum. If this can be achieved then under most circumstances there should be no necessity for any discrimination between men and women when it comes to the work that can be undertaken.

See para 96 which deals with pregnant workers.

50. Summaries of dose assessments should be reviewed routinely, by the employer (usually the RPO acting on behalf of the employer), to ensure that any dose constraint target is being met.

51. In order to minimise the exposure to ionising radiations, one needs to appreciate the properties of the ionising radiations and the two principal hazards which they can present.

52. Radiation hazards can be split into two broad groups: the external hazard, arising from a radiation field that is outside the body; and the internal hazard which follows from the incorporation of radioactive material into the body. Some radiation sources only present an external hazard some only an internal hazard. Some however have the potential for both types of hazard.

See para 1, Justifying work practices

53. Risks from ionising radiations should be minimised by using the optimum choice of radionuclide or x-rays consistent with experimental requirements. The use of techniques not involving ionising radiations must also be considered.

Restricting the External Hazard

See Appendix 1 for useful information on restricting the external hazard

54. External hazards can be found in the vicinity of x-ray sets whilst they are operating and from both sealed and unsealed sources of radioactive material. Generally the higher the activity of radioactive material and the more penetrating the radiations given off the more intense is the radiation field at a given distance from the source. The hazard is therefore mainly associated with gamma and neutron sources and the more energetic beta emitting sources. All can give significant effective doses. However, even low energy beta and alpha emitting sources can, if actually on the skin (alpha) or, if in sufficient quantity as contamination on gloves (low energy beta), deposit sufficient energy to cause deterministic effects in the form of localised skin burns.

Internal Hazard

55. Open or unsealed sources of radioactive material may be taken into the body through the mouth or other orifice, or inhaled as a dust, gas or vapour through the nose or mouth, or enter through a cut or abrasion of the skin. Certain elements and compounds, e.g. iodine, can also be directly absorbed through unbroken skin. If absorbed by the body the radionuclide is dealt with in exactly the same way as the stable element. Once absorbed into an organ or tissue it cannot be clinically removed preferentially and leaves the body according to the normal biological turnover of that element or by radioactive decay. As it decays it gives off its radiations

some or all of the energy of which will be absorbed by the body. The ingestion of even very small amounts of radionuclides can result in significant radiation doses.

56. Internal contamination can be minimised by adopting good working practices, and by following some basic safety precautions such as:-

- use of materials of minimum radiotoxicity;
- presence in the laboratory of the minimum quantities;
- containment, to prevent spread of contamination;
- cleanliness and good housekeeping;
- use of appropriate protective equipment;
- good personal hygiene;
- no eating, smoking, drinking or applying of cosmetics;

See Appendix 9 - Radiological Compliance Audit Check-list.

and by the auditing of the working practices.

57. The good working practices required for work with unsealed sources should be set out in Laboratory Rules, which should be posted in every laboratory.

From ICRP 68: Dose Coefficients for Intakes of Radionuclides by Workers (*Ref C2*)

58. A useful indication of the radiotoxicity of a radionuclide is given by knowledge of the dose coefficients. In the table below the most restrictive effective dose coefficients are used for the common isotopes.

<u>Radionuclide Sv/Bq Intake for 1mSv dose</u>

H-3 water 1.8×10^{-11} 55.6 MBq

H-3 (OBT) 4.2×10^{-11} 23.8 MBq

C-14 5.8×10^{-10} 1.7 MBq

P-32 3.2×10^{-9} 0.31 MBq

P-33 1.4×10^{-9} 0.71 MBq

S-35 1.3×10^{-9} 0.77 MBq

Ca-45 2.7×10^{-9} 0.37 MBq

Cr-51 3.8×10^{-11} 26.3 MBq

$Tc\text{-}99^{m}$ 2.9×10^{-11} 34.5 MBq

I-125 1.5×10^{-8} 66 kBq

I-131 2.2×10^{-8} 45 kBq

Contamination Control

Surface contamination monitoring

- see also paras 83-87

59. It is recommended that there should always be a suitable contamination monitor available in areas where unsealed sources are used. It is useful to have a check source available (e.g. securely attached to the ratemeter) so that the monitor can be tested before and during use, to make certain that it is functioning correctly. Every time radiochemicals are manipulated the appropriate monitor should be used to monitor the worker and the immediate work area - bench top, equipment, bench front and floor. Any contamination found should be removed immediately, or if this is not practicable, a suitable warning notice should be displayed. On no account should contamination be left unmarked which could pose a hazard to others.

See Appendix 10 - Surface Contamination Action Levels

60. At regular intervals, depending upon the grade of the laboratory, a full monitoring survey should be carried out to establish that:-

- the area is correctly designated (on grounds of contamination);
- contamination has been kept as low as reasonably practicable; and
- any contamination that has occurred has been dealt with efficiently and has not been spread to - telephone, refrigerator doors, cupboard doors, floors, door handles, etc.

See Appendix 6 - Wipe tests for tritium

These monitoring surveys must be recorded.

61. Most contamination monitors cannot detect the weak beta emissions from tritium, therefore wipe tests must be performed using moistened filter papers, or other suitable medium, and sampling a known area.

guarding against air hazards

(Ref B2)

62. Many operations involving radionuclides can pose potential air contamination hazards arising from either their natural volatility or aerosol or dust generation. Manufacturer’s guidance on the handling of individual radionuclides must be carefully adhered to and proper use made of aerodynamically designed and tested fume cupboards. Materials in powder form, unless immediately dissolved in a solvent, will need to be handled in a glove box. Providing the correct containment is employed and given the level of usage, air monitoring should not normally be necessary.

63. Significant discharges to atmosphere through fume cupboards must be assessed by appropriate means to ensure that waste authorisations are not exceeded.

Decontamination Procedures

64. Instigate decontamination procedures as soon as possible after contamination has occurred, except in the following circumstances:-

(a) the contaminated item is disposable and can legitimately be disposed of as solid radioactive waste; or

(b) the radionuclide is of such short half-life (no more than a few hours) that, if the contamination was left, it would rapidly decay away.

See Appendix 2 on Decontamination procedures

65. In the case of (b) above, one is concerned not to expose personnel unnecessarily to hazardous radiations during the cleaning process. Any area left with a high level of contamination should be clearly and prominently marked, to keep people away from it until the radionuclide has safely decayed.

66. Any decontamination exercise should always start with the mildest cleaning agent, e.g. soap and water, before moving on to harsher treatments. The cleaning process should always commence from the outer extent of the contamination and proceed towards the centre, to avoid spreading the contamination.

67. If contamination is not readily removed, then before taking drastic action other options should be considered. It may be possible to cover the contaminated area whilst the radioactivity decays away, e.g. use a sheet of perspex on the bench to cover contamination by P-32. If the contamination is permanently fixed then an assessment of the external hazard should be made - this may indicate an insignificant potential exposure. Painted surfaces can be stripped and 'Corian' benchtops can be wet rubbed-down with emery paper. When removing contamination in this way be aware of any air contamination hazard that may be created.

Incident Reporting

See also Environment Agency Guidance (*Ref E11)*

68. All major contamination incidents should be reported to the employer, e.g. via the RPO. Examples of what would be considered major incidents in most establishments are: contaminated individuals; spillage of stock material in the laboratory; and contamination spread outside the working area.

69. Other incidents that should be reported are: any significant dose on a direct reading dosemeter or unexpected reading on a dose-rate monitor; damage to a sealed source; or any failure of an interlocked enclosure.

See Appendix 11 - Record Keeping

70. The employer will be responsible for investigating the incident, recording the details of the incident for future reference, reviewing risk assessments where necessary and deciding whether the incident needs reporting to a higher authority.

See also Notification of Certain Occurrences - paras 156-157

Designation and Monitoring of Areas

IRR - Reg 16

see ACOP paras 248 - 271

(*Ref A3*)

Controlled Areas

71. In an area where a risk assessment has indicated that either:

- effective doses in excess of 6mSv are likely to be received in a year; or
- equivalent doses in excess of 3/10 of other relevant limits are

likely to be received in a year; or

- where special written procedures, specific to the area, need to be followed in order to restrict doses to less than 6 mSv per annum;

then that area will be required to be designated as a Controlled Area.

Special procedures mean more than just simple commonsense precautions such as working with volatiles in a fume-cupboard or working behind a screen. A risk assessment should consider whether without the procedures an individual was likely to receive a significant radiation exposure that over a period of time could result in the other conditions for designation of a controlled area being reached.

Good practice procedures that should not be considered special include: working over a tray; working behind screens; use of a fume-cupboard for volatiles; use of PPE such as lab-coat and gloves; use of localised shielding; use of small handling tools; personal and area monitoring.

Supervised Areas

72. Supervised Areas are those where a risk assessment has indicated that effective doses are likely to exceed 1mSv per year and/or where working conditions of an area need to be kept under review to ensure that designation as a controlled area is not required.

Non-Designated Areas

73. Areas that do not require designation as either Controlled or Supervised areas, because effective doses to personnel are not likely to exceed 1mSv per annum, shall be referred to as 'non-designated areas'. (In some Establishments these may be referred to as 'low-level areas', ‘tracer areas’ or 'registered areas'.)

Designation in relation to the External Hazard

See ACOP paras 248 and 339

(*Ref A3*)

74. In determining the designation of an area in relation to the external hazard the likely instantaneous dose-rates in an area should be established. If the whole body is likely to be exposed to dose-rates in excess of 7.5 microsievert h^{-1} for over 16 hours a week or the hands are likely to be exposed to dose-rates exceeding 75 microsievert h^{-1} then a controlled area will be required.

75. If occupancy rates were greater than 8 hours a week at a dose-rate of 2.5 microsievert h^{-1} then that would mean an annual dose in excess of 1mSv could be expected and the area would therefore have to be designated a supervised area.

76. If dose-rates in an area are less than 2.5 microsievert h^{-1} then official designation of the area is unlikely and the risk assessment may show that the area can be classified as 'non-designated'.

77. The shielding normally used should be taken into account in making any assessment. Temporary designation at a higher level may be needed at times of source changing in relation to sealed source work and when bypassing interlocks to carry out alignments in x-ray optics work.

See Appendix 1 on protection from the external hazard

Designation in relation to the Internal Hazard

See ACOP para 339 (*Ref A3*)

78. When working with unsealed sources sometimes it is the internal hazard that poses the greatest risk and determines the level of designation of the area.

79. The risk of internal hazard not only depends on the activities being handled but also depends upon the quality of surface finishes of the laboratory and the level of containment used to control the hazard.

80. Various models can be used to relate activities handled to potential doses that may be received. Establishments must consult with their RPA as to the levels of activity that can be safely handled in designated areas consistent with the requirements of Regulation 17. Some radiation employers, for reasons of quality control or contamination control, may wish to set lower limits than those indicated by the models for the designation of areas.

See Appendix 3

for examples of models used to determine potential doses

Designation where there are both Internal and External Hazards

81. In most models the potential internal dose is relatively low and it will be the control of the external hazard, and whether or not special procedures are required to ensure this, that will determine the need, or otherwise, for a controlled area. Where radionuclides present both an internal and an external hazard then a realistic assessment should be made of the likely doses that will result from the proposed work and every effort must be made to reduce these by the use of appropriate shielding.

Determining appropriate Limits for Non-Designated Areas

See - Appendix 7 col.3 of Table of common radionuclides from schedule 8 of IRR99

82. The quantities of radionuclides that do not require notification under Reg 7 are given in column 3 of Schedule 8 to the Regulations.

These figures, taken from Annex 1 of the Basic Safety Standards, equate to likely doses to the general public of not more than 10 microsieverts in a year from any given radionuclide and take into account both the internal and external hazard that the radionuclides present. Ten times these amounts would therefore equate to 100 microsieverts in a year and this would be well below the level that would require a supervised area according to Reg 16(3). These quantities could therefore be used as one

basis for determining the limits to be applied to non-designated areas.

Monitoring

Monitoring of Designated Areas

IRR 99 - Reg 19

See ACOP 339 - 356 (*Ref A3)*

83. There is a legal requirement under Regulation 20 to ensure that all designated areas are adequately monitored. The quantities that need to be assessed are surface contamination and dose-rate. This is to help show that the correct designation has been applied and that contamination and radiation levels are being kept under control.

See Appendix 10 - Surface Contamination Action Levels

See -HSE information sheet IRP7 on 'Selection, use and maintenance of portable monitoring equipment' (*ref A18*)

84. It is recommended that there should be an appropriate contamination monitor present in every laboratory where unsealed source work is carried out. In x-ray laboratories an appropriate x-ray monitor should be present. With sealed sources and for work with neutron generators, it is not essential for a monitor to be kept in the laboratory but an appropriate dose-rate instrument or suitably calibrated contamination monitor should be readily available to the radiation workers and they need to be made aware of its whereabouts.

See ACOP para 362 for what constitutes suitable records

(Ref A3)

85. Some records of monitoring must be kept. A record need not be made every time the monitor is used, but every time a survey is undertaken the results should be recorded and kept for a minimum of two years for reference. The frequency of such surveys will depend upon the use and designation of the area. If a controlled area is used by a number of research groups for radionuclide dispensing or iodinations then a survey should be performed and recorded at the end of each period of use. For a supervised area used by one research group weekly to monthly recorded surveys have been found to be adequate. Local circumstances should be discussed with the RPA and agreed procedures written into the Local Rules.

Monitoring of Non-Designated Areas

86. Under IRR99 there is no specific requirement for monitoring or recording of monitoring for non-designated areas. However there is a general duty to restrict exposure under Reg 9 and general requirements to minimise contamination under RSA93.

87. It is advisable, therefore, to have monitoring instruments readily available for use in non-designated areas and some recording of monitoring surveys is recommended in order to demonstrate that the areas non-designation is justified. A regular (e.g. every two months) recorded monitoring survey should be sufficient for these purposes.

Monitor Testing

IRR - Reg 19(2)

See ACOP 347 - 366 (*Ref A3*)

See -

National Physical Laboratory Good Practice Guide (GPG 14)

88. Dose-rate and contamination monitors should be tested and thoroughly examined on an annual basis by a 'qualified person', or under the supervision of such a person. Establishments may have their own 'qualified person' or they will need to send instruments away for calibration by an appropriate test house.

89. The RPA should be consulted over the nature of the tests required and

Good Practice Guide (GPG 14)

(*Ref E4*) and

AURPO Guidance Note No.4

Periodic Testing of Contamination Monitoring Instruments (*Ref D1*)

See Appendix 11 - Record Keeping

the suitability of the test house. Although this is only a legal requirement for instruments used in designated areas it is recommended good practice for all monitoring instruments.

90. Records of these tests should be kept for a minimum of two years.

'qualified person' - should possess the necessary expertise in instrumentation, theory and practice appropriate to the type of instrument to be tested.

Dose Limitation, Classification and Monitoring of Persons

Dose Limitation

IRR Reg 11(1) and

Schedule 4 Part 1

See ACOP paras 181- 205

(*Ref A3*)

91. There is a statutory requirement to ensure that exposures to ionising radiations are kept below specified limits. Except in exceptional circumstances, the following annual limits must be observed:-

Exceptional circumstances

See - IRR Reg 11(2) and

Schedule 4 Part II

92. For employees 18 years or above

- 20 mSv whole body exposure

- 150 mSv to the lens of the eye

- 500 mSv to the skin and extremities

93. For trainees (16 or 17 years old)

- 6 mSv whole body exposure

- 50 mSv to the lens of the eye

- 150 mSv to the skin and extremities

94. For others

- 1 mSv whole body exposure

- 15 mSv to the lens of the eye

- 50 mSv to the skin and extremities

Pregnant women

-see IRR Reg 8(5)

95. There is also a limit on the exposure of women of reproductive capacity of 13mSv in any consecutive 3 month period. There is no specific prohibition of pregnant workers from working with ionising radiations in laboratories but a prior risk assessment should have taken the possibility of pregnant workers into account. When a pregnancy has been declared an

Management of Health and Safety at Work Regs - Reg 16

(*Ref A8)*

equivalent dose limit of 1 mSv should be applied to the foetus.

Working safely with ionising radiations: Guidelines for expectant or breastfeeding mothers (*Ref A19*)

See IRR Reg 14(c)

96. Employers must inform pregnant women of the importance of the reporting of their pregnancy in writing* so that any additional protection measures can be undertaken. In general, taking into account the radionuclides and quantities used in research laboratories, external radiation should not be a risk to the foetus, especially if it is from a beta emitter and normal good working practices are followed. However, the internal hazard may be a factor. This is dependent on the quantities and radionuclides used - assessments may be required. It is prudent to take extra care with personal hygiene and minimise surface and airborne contamination. Pregnant women should not be asked to deal with clean-up operations after a large spill and if they have been directly involved with a large spillage they should not resume work with unsealed sources until after a dose assessment has given them the all clear.

** This will not be necessary if a prior risk assessment has already established that an equivalent dose of 1 mSv to the foetus is unlikely to be exceeded. However, if this policy is followed it is important to make sure that induction training covers the issue of risks to pregnant workers.*

See Appendix 3 - Designation where female workers are involved

97. Where radionuclides with more penetrating radiations are used, the potential exposure needs to be assessed carefully and should be discussed with the pregnant worker.

Nursing mothers See Reg 8(5) and Reg 14(c)

98. Where a nursing mother is involved in radiation work, the risk assessment needs to be reviewed especially with regards to the potential for internal contamination as above. It is important that the nursing mother informs the employer in writing unless it has already been established that the risk to the nursing mother will be minimal.

IRR Reg 2(3)

Students treated as employees

99. Students and trainees aged 18 years or over are treated as employees under the definitions of the regulations. However, in all work with undergraduates or other trainees in a research environment it should be possible to plan all experiments such that one can ensure that the dose limits for ‘others’ are not exceeded.

Designation of Classified Persons

IRR Reg 20

See ACOP paras 367- 380

(*Ref A3*)

100. An employee who is likely to receive an effective dose in excess of 6 mSv per year or an equivalent dose in excess of three-tenths of any relevant dose limit shall be designated as a "Classified" Person. Persons classified as such must be informed of this. Employees/trainees under the age of l8 years can not be designated as classified persons.

101. Most research and teaching radiation workers are unlikely to receive whole body doses in excess of 6 mSv per annum. Designation on these grounds will therefore be very limited.

See section on designation of areas - paras 71 - 81

102. Although worker doses may be low, some operations may require the setting up of ‘controlled areas’. The employer must then decide whether to classify the workers entering such areas or to ensure that their exposures are suitably restricted by following special written procedures.

See section on co-operation

103. Work at other establishments might require entry into controlled areas

between employers - para 32

See also paras 116 - 118

and the other radiation employer may insist on all people working in such areas being registered as ‘outside workers’.

IRR Reg 24(2)

See - Medical Surveillance

paras 122-124

104. The decision as to whether to designate a worker as classified, or not, will have to be taken by the employer after consultation with the Radiation Protection Adviser and the appointed doctor or employment medical adviser. (Establishments who have classified workers must have access to an appointed doctor or employment medical adviser as part of their medical surveillance programme.)

105. Before any person may become a Classified Person, they must undergo medical examination by an appointed doctor and be declared fit for radiation work; they must then remain under medical surveillance until they cease to be so designated.

Dose assessment and recording

IRR 99 Reg 21

See paras 113 - 115 for the Role of the ADS

106. An employee who is a Classified Person must be subject to appropriate personal dosimetry, by an Approved Dosimetry Service (ADS), in order that any significant doses of ionising radiation are systematically assessed and recorded. Dose records must be kept for at least 50 years.

107. The level of personal dosimetry for non-classified workers should be determined by the employer, in consultation with the RPA, after taking into account any risk assessments. Typically, all those working with penetrating radiations in controlled and supervised areas will be monitored to demonstrate that the area has been correctly designated and provide staff reassurance. It is not necessary to monitor people who only work in non-designated areas although some employers may wish to do so for staff reassurance.

108. Records of monitoring of non-classified workers should be kept for at least 2 years.

AURPO Recommendation

See also Appendix 11 - Record Keeping

Monitoring the external hazard

Devices used for monitoring the external radiation hazard.

109. Work involving penetrating radiations in controlled and supervised areas will normally require personal dose monitoring utilising either film badges or thermoluminescent dosemeters (TLDs). It is important that these are worn as instructed and returned promptly for processing. In some circumstances, it may be advantageous to use electronic personal dosemeters (EPDs) which can give immediate information on dose-rates and dose.

110. Work involving weak beta emitters such as H-3, C-14 and S-35 does not create a significant external hazard and no monitoring for this is required.

111. Thermoluminescent dosemeters are also available to measure extremity doses (for example, to the fingers with TLD rings). These are of value when: using hard beta emitters such as P-32; sealed sources are being handled; or, during the alignment of some x-ray crystallographic sets.

Monitoring the Internal Hazard

112. When significant quantities of unsealed sources are handled in controlled areas, or when an accidental intake is suspected in other areas, then there is a requirement to undertake biological monitoring. This can take the form of whole body counting for gamma emitters, thyroid counting for radioiodines and urine or faecal analysis for other isotopes. Simple measurements to demonstrate 'alara' may be undertaken in departments. An 'action level' of 1% of the relevant dose limit should be used to trigger more detailed assessments.

See Appendix 8 - Biological Monitoring

The Role of the ADS

IRR 99 Reg 21(3)

113. For dose assessment of classified workers, an Approved Dosimetry Service (ADS) must be used; sometimes more than one ADS may be required, for example, for internal and external dose assessments. Most ADSs will provide a record keeping service. Where a number of ADSs are used only one can be used as the record keeping service; other ADSs used should be informed of the body acting as co-ordinator for the record keeping service. It is normal practice for the ADS to maintain records for non-classified personnel as well.

114. For record keeping purposes, the Radiation Protection Adviser and Approved Dosimetry Service must be promptly informed when any person designated as a Classified Person leaves or intends to leave the establishment so that a termination record can be provided. Normally persons are declassified at the end of the year but if a classified employee leaves before the end of the calendar year a termination record should be obtained and forwarded to them.

Termination Records

IRR99 Reg 21(6)

115. An appointed doctor or employment medical advisor can declassify a worker at any time during the calendar year if the worker is deemed unfit to continue work with ionising radiations.

Visiting Workers and Outside Workers

116. If visiting radiation workers or other persons are to enter controlled or supervised areas, then arrangements must be made to ensure that the appropriate dose limits are not exceeded. Long term visitors should be treated the same way as employees. For monitoring the exposure of short term visitors electronic personal dosemeters (EPDs) are particularly useful.

IRR 99 Reg 21(5)

117. In circumstances where a classified worker carries out services in the controlled area of another employer, that person is termed an 'outside worker'. All outside workers should be in possession of a 'radiation passbook' in which details of their outside work, any doses received and of

See ACOP paras 398-413

(*Ref A3*)

their ‘fitness to work’ can be recorded. It should be noted that regulations relating to outside workers do not apply if the ‘outside worker’ takes over management of the controlled area for the duration of the work.

See IRR99 Schedule 6 - records to be made in radiation passbooks

Educational visits

See also ACOP para 317

118. Where a classified person visits another radiation employer’s controlled area for the sole purpose of an educational visit, they shall not be regarded as an outside worker on this occasion and a radiation passbook will not be required.

Estimated Doses and Special Entries

IRR 99 Reg 22(1)

See ACOP para 415-419 (*Ref A3*)

119. If personal dosemeters are lost, damaged or destroyed, the employer must make an investigation in collaboration with the RPA. (This is a statutory requirement only in relation to classified workers.) Where a dose can be estimated, this value, together with supporting information, must be sent to the ADS. Where there is no estimate available then the ADS will automatically enter the appropriate notional dose for classified personnel.

IRR 99 Reg 22(3)

See ACOP paras 420-437

(*Ref A3)*

120. Where there is any reason to doubt the validity of a personal dose assessment, or if abnormally large or unexpected doses are recorded, an investigation must be made by the employer in consultation with the RPA. The subsequent report shall be kept for at least two years. Where the dose record needs to be changed this can be recorded by the ADS as a ‘special entry’. Again these procedures are only required in respect of classified workers. An ADS can not be asked to amend a dose record, without the consent of the HSE, where a dose limit has apparently been exceeded. A classified worker who does not agree with a special entry has three months to appeal in writing to the HSE.

IRR 99 Reg 22(8)

IRR 99 Reg 22(6)

IRR 99 Reg 23

Dosimetry for Accidents

121. In the event of an accident that might result in significant personal contamination or a significant dose being received, the RPS and RPA must be informed immediately so that appropriate action can be taken. In the case of a classified worker, where the effective dose may exceed 6 mSv, the dosimeter must be returned for immediate assessment. A special dose assessment needs to be made. Once completed, the person(s) must be informed of the result of that assessment and a record of that assessment kept for 50 years minimum or until the person has attained the age of 75 years.

IRR Reg 24

Medical surveillance

See ACOP paras 444-468 (*RefA3*)

122. Arrangements must be in place to provide medical surveillance for classified personnel and others that have been involved in an accident or incident and received an overexposure.

123. Classified workers must have a pre-employment medical and then a review of health on an annual basis or such shorter period as determined by the appointed doctor or employment medical adviser. It is not usually

necessary for a full medical, including blood count, to be undertaken at each review. The appointed doctor should discuss with the RPA the nature of the work undertaken and the dose records for the past year in determining what is necessary.

IRR 99 Reg 24(3) - Schedule 7 gives details of particulars to be contained in a health record.

124. Health records need to be kept for 50 years from the date of the last entry.

See Appendix 11 - Record Keeping

Overexposure

IRR Reg 25

125. Where it is believed that a person has or is likely to have received an overexposure for the monitoring period, then the employer should carry out an investigation. In practice this will normally be undertaken by the RPO in consultation with the RPA. Where an overexposure has been confirmed, the person exposed must be informed of the results and any measures to prevent reoccurrence. There is a statutory duty to inform the Health and Safety Executive and appointed doctor (or employment medical adviser) as soon as practicable. Where the person is an employee of another employer, there is a duty to inform that employer in addition to those above.

126. The employee will also be required to have a medical examination and the results of this will have to be kept for 50 years as indicated above.

127. Where necessary, measures must be introduced to further limit doses for the remaining dose limitation period.

IRR Reg 26

Control of Radioactive Substances, Articles and Equipment

Storage of radioactive substances

IRR Reg 29(1)

Requirements of conditions of Registration under RSA1993

See- HSE information sheet IRP8 Control of Radioactive Substances (*ref A20*)

128. Radioactive sources, sealed and unsealed, must at all times except when actually in use or while being moved, transported or disposed of, be kept in suitable containers in a suitable store. Containers should prevent dispersal of the radioactive material. Containers must be appropriately labelled and suitable for the purpose, having particular regard to shielding, containment and the potential hazards likely to be encountered.

129. Stores should be appropriately labelled and provide weather protection (if necessary), resistance to fire, security, ventilation and appropriate shielding. Shielding should ensure that the dose-rate outside the store does not exceed 7.5 microsievert h^{-1} and if practicable less than 2.5 microsievert h^{-1}.

130. The correct temperature of storage is very important to avoid decomposition of many radiochemicals and the importance of this must be

stressed to users.

131. Where a fridge/freezer is used for storage of radiochemicals it should be either dedicated for this purpose or, in small laboratories, an area/shelf within the fridge/freezer should be reserved for radiochemical storage. In both cases the fridge/freezer must be kept locked unless it can be clearly demonstrated that there is sufficient control to prevent access by personnel not authorised to use the sources. In some circumstances it may be permissible to have a locked store inside a fridge/freezer. (NB the fridge/freezer must be spark proof if contents are flammable.)

Leak Testing of sealed sources

IRR Reg 27

ACOP para 483-492

132. Leak tests must be carried out on sealed sources at regular intervals not exceeding two years. Some Establishments carrying out their own leak tests find it useful to combine these with an annual audit of all sealed sources. It is not always practicable to directly leak test some sealed sources because of inaccessibility or because of high dose-rates involved. In these circumstances an accessible surface, likely to be contaminated in the event of a leakage, should be tested.

Example of leak test

See BS DD 66:1980 (*Ref B3*)

133. A wipe test, carried out with a moistened swab, is a typical technique that is used. The swab should be presented to an appropriate monitor in a low background area. If the activity on the swab is less than 185 Bq the sealed source is considered to be leak free.

134. An appropriate record needs to be made and kept for at least 2 years.

135. Sources whose activity is so low that accounting procedures are not required, or discrete sources with physical dimensions less than 5mm, may be exempt from testing with the agreement of the Radiation Protection Adviser.

Activity of source less than that specified in col.3 of schedule 8 of IRR99

See ACOP guidance para 501

(Ref A3)

136. Liquid scintillation counter sources, which are generally inaccessible, should be included in an annual audit but do not need to be physically leak tested as the operation of the machine tests the integrity of the source each time it is used.

Accounting for radioactive substances

IRR 99 Reg 28

Includes requirements of RSA93

ITN/RSA/10 - Guidance on retention of records (*Ref E5*)

See Appendix 11 - Record Keeping

137. Departments must compile records of the activities and locations of radioactive sources, sealed and unsealed, and these should be kept for at least two years after the record was made. Accounting for sources must commence immediately after delivery and records should contain the following:-

- means of identification
- date of receipt

- activity on date of receipt
- whereabouts of source - updated regularly
- date and manner of disposal/removal
- activity on date of disposal/removal

Retention of Records (*Ref E5*)

See also Appendix 11

138. Records of disposal should be kept for a minimum of 4 years (5 in Scotland) and indefinitely for 'special precautions burial' and disposal of long-lived radionuclides to drain (except H-3 and C-14).

139. Sealed sources will be uniquely identified and need to be kept both on a local and central register. The central register will demonstrate compliance with the corresponding Registration Certificate.

ACOP paras 493-501 (*Ref A3*)

140. A minimum of monthly checks should be made on the location of all sealed sources and where sources are used in different laboratories or areas, they should be logged in and out of an appropriate locked store. Whilst out of the store the location of such sources may need to be monitored on a daily basis - guidance on this should be sought from the RPO/RPA.

141. The purpose of such records is to enable any losses to be identified quickly. Any 'missing' sources must be reported immediately to the employer (usually the RPO acting on behalf of the employer) who has a legal duty to report any loss to the Environment Agency, the Police and possibly the HSE.

See - Notification of Occurrences paras 156-157

142. In every establishment a regular audit (at least annually) of sealed and unsealed sources should be undertaken to ensure that the accounting record is a true record. This should be carried out under the auspices of the RPO.

Disposal of radioactive substances

RSA 1993 Section 13

Conditions of Waste Authorisations

143. Disposal of radioactive waste in any form is subject to control by the Radioactive Substances Act l993 (and a number of current Exemption Orders).

144. Establishments are permitted to dispose of such waste only by specified methods, within specified limits and subject to specified conditions. They need to have arrangements in place which detail the current methods used, the limits that are applicable and the procedures to be followed.

145. As part of the accounting procedure, in situations where Waste Authorisations are shared between a number of departments, collation of records centrally on a monthly basis will be necessary to demonstrate compliance with the authorised limits.

Movement of Radioactive Substances

IRR 99 Reg 29(2)

ACOP paras 502-511

146. When a radioactive substance is moved on the employer's premises it needs to be suitably packaged and labelled for the movement. Common-sense will determine what is necessary to protect the user and others. Shielding should minimise the dose to the carrier and packaging should be such that if the source is dropped the containment system will ensure that

there is no spillage. The labelling provided for storage should in most circumstances be adequate for any movement.

Transport of Radioactive Materials

Radioactive Material (Road Transport)(Great Britain) Regulations 1996 (*Ref A9)*

IATA - Dangerous Goods Regulations *(Ref C6)*

147. Whenever radioactive sources, sealed or unsealed, are to be transported, they must be packaged, labelled and carry documentation in accordance with the requirements of the relevant transport regulations. Packages received from recognised commercial suppliers can be expected to be properly packaged, labelled and documented, this being the consignor's responsibility.

148. Where an institution receives radioactive material centrally for onward transmission to an end user it is recommended that there should be an audit trail in place whereby at every transfer situation the goods are signed for.

149. If a Department is the consignor, then responsibility for complying with the transport regulations rests with the Radiation Protection Supervisor or individual making a consignment who should, if necessary, seek the advice and assistance of the Radiation Protection Advisor.

See - AURPO Guidance Note No.6 Transport of Radioactive Materials by Road (*Ref D3*)

-includes requirements on driver training.

150. Vehicles used to transport radioactive sources, either to or from the establishment or as part of a programme of work, are also subject to the requirements of regulations. This could mean displaying vehicle signs and placards and carrying fire extinguishers if carrying labelled packages. Driver training is also required in certain circumstances. Those responsible for arranging the transport of radioactive sources must ensure that the insurance policy for the vehicle allows its use for such a purpose. NB It is normally only fissile radioactive materials and nuclear waste that is excluded in motor insurance policies.

Transport of Dangerous Goods (Safety Advisers) Regulations 1999 (*Ref A14)*

151. There is a requirement to appoint a Dangerous Goods Safety Adviser (DGSA) if you are the consignor or carrier of Type A packages on a regular basis.

Are you involved in the transport of dangerous good by road or rail? (INDG234(rev), 02/99)

(*Ref A15*)

152. There is no requirement for a DGSA if you are only involved in the transport of excepted packages, or if your involvement is limited to the occasional transport of up to 10 Type A packages with a combined transport index of less than 3. Providing the employer has appointed an RPA who has the knowledge and experience to advise on the relevant transport regulations and the transport of radioactive materials is not a main or secondary activity then the HSE should be flexible in the interpretation of the DGSA regulations.

Off-site use, loan and transfer of sources

RSA 93 Section 10

153. Sealed sources can be covered by a ‘mobile licence’ that permits apparatus containing a radioactive source to be used at various locations subject to the conditions of the licence and under the responsibility of the licence holder.

154. It should be noted that ‘mobile licences’ are restricted to territorial boundaries and sources cannot be used in Scotland under a licence issued for England and Wales.

155. Sources cannot be loaned to other establishments unless that establishment has a registration that permits their use. Before transferring any material to another establishment a copy of that establishment's registration certificate should be obtained to establish that they are authorised to use the material.

Notification of certain occurrences

IRR 99 Reg 30(1) and column 4 of Schedule 8

See Appendix 7 for summary from Schedule 8 to IRR99

156. The release to atmosphere or spillage of a quantity of radioactive material in excess of specified amounts must be reported immediately to the employer (usually the RPO acting on behalf of the employer). An investigation will be required into the circumstances and quantities involved. Then, as appropriate, it is the employer's responsibility to notify the Health and Safety Executive and Environment Agency forthwith.

IRR 99 Reg 30(3) and column 5 of schedule 8

See Appendix 7 for summary from Schedule 8 to IRR99

See also Environment Agency Guidance (*Ref E11)*

157. If there are any grounds to believe that a radioactive substance, has been lost or stolen, this must be reported immediately to the employer (usually the RPO acting on behalf of the employer). An investigation will be required into the circumstances and quantities involved. Then, as appropriate, it is the employer's responsibility to notify the Health and Safety Executive, Environment Agency and Police forthwith.

Duties on manufacturers

IRR 99 Reg 31

See ACOP para 518 - 522

(*Ref A3*)

158. Where a manufacturer is installing a piece of equipment that emits ionising radiations, he has a duty to ensure that it is fit for the purpose intended, that all safety features and devices are working properly and that users will be adequately protected. It is the responsibility of the manufacturer to ensure that this examination is carried out. The manufacturer must have consulted an RPA with regard to the critical examination but the RPA does not have to be present. Alternatively, as long as it is clearly agreed in writing, it can be the user's RPA who supervises the final trials, but the responsibility is still the manufacturer's/installer's.

See ACOP para 523 – 526

(*Ref A3)*

159. If the manufacturer is carrying out the examination and does not have an RPA present then the engineer carrying out the examination must be working to a clear protocol for the equipment at that specific location. If for some reason the original installation procedure has to be changed, then the manufacturer's RPA must be involved again before the critical examination is carried out. It may be necessary to set up a temporary controlled area during set-up and alignment procedures. Normally, the engineer carrying out the procedures will be in charge of the area during this time. Non-classified personnel will not be permitted to be present in the controlled area unless they are operating under a written system of work. The local RPA will need to agree to any arrangements and if practicable be present. They should also review the installation to ensure that it has been carried out in accordance with Regulation 31.

Equipment/Radioactive Substances used for medical exposure

IRR 99 Reg 32

See ACOP paras 527 - 557

160. Special conditions apply when ionising radiation is deliberately used on human beings in the medical and dental fields for the purposes of diagnosis, therapy and research. If your work involves this area you should refer to the current Medical and Dental Guidance Notes *(Ref E12).*

Appendix 1 - PROTECTION FROM THE EXTERNAL HAZARD

Doses can be minimised by :-

a. **keeping one's distance** - sources must never be directly handled using fingers,
b. **use of effective shielding**,
c. keeping the exposure **time** to a minimum,

and, in the case of work with radioactive materials optimising the amount used.

Keeping One's Distance

The dose-rate associated with any point source of gamma or x-radiation is inversely proportional to the square of the distance from the source - the inverse square law -

$$D \propto \frac{1}{r^2}$$

Therefore, doubling the distance from the source, reduces the dose-rate by a factor of 4.

Always remember **closeness endangers - distance protects**.

A useful expression for estimating dose-rates from penetrating beta emitters is:-

D = 760A D is the dose-rate in microsieverts h^{-1} at a distance of 10 cm

from a point source

A is the source activity in MBq

(*From work by Prime and Frith, Univ of Manchester published in Radioisotopes in Biology by Slater, p.13*)

A useful expression for calculating the approximate dose-rate from a gamma source is:-

$D = \frac{ME}{6r^2}$ D is dose-rate in microsievert h^{-1}

$6r^2$ M is activity in MBq

E is energy/disintegration in MeV

r is distance from source in metres

(*From an Introduction to Radiation Protection by Martin and Harbison, p.78*)

Both of the above expressions assume no shielding, and a monitor should always be used to establish the true dose-rate.

The table below gives some examples of dose-rates at 1 m from 10 MBq sources, using information on the energy and intensity of their gamma emissions from ICRP publication 38.

Radionuclide	γ- dose-rate in microsievert h^{-1}
Na-22	3.65
Cr-51	0.05
Fe-59	1.98
Co-57	0.21
Co-60	4.17
1-125	0.07
I-131	0.63

Use of Shielding

Beta particles are best shielded by materials of low atomic number to prevent the production of bremsstrahlung: Perspex makes good shields, because it is robust and easily worked. Glass is also very effective, and thick walled glass vessels are particularly useful. The table below shows the thickness required for complete shielding from beta particles.

E max (MeV)	0.5	1.0	2.0	3.0
Glass	lmm	2mm	4mm	7mm
Perspex	2mm	4mm	7mm	12mm

Gamma rays and x-rays are far more penetrating than beta particles of the same energy and require dense shielding materials - lead is the material that is usually used. They are attenuated exponentially, and a knowledge of the half-value layer (HVL) or tenth-value layer (TVL) is useful in determining the amount of shielding required. 1 HVL is the thickness required to reduce the intensity to one half the incident value and 1 TVL is the thickness needed to reduce the intensity to one tenth the incident value. Some approximate values of HVL and TVL are given in the table below.

Gamma energy	millimetres of lead shielding

MeV	HVL	TVL
0.5	4	12.5
1.0	11	35
1.5	15	50
2.0 19	60	

Appendix 2 - DECONTAMINATION PROCEDURES

NB All personnel involved in decontamination procedures should be protected by the use of appropriate PPE and some chemicals used may require COSHH assessments to be made.

Glassware

For glassware, use an alkaline detergent, proprietary decontaminating solutions, or ammonium citrate.

Plastics

For plastics, treat as for glassware, and in addition, dilute nitric acid is sometimes effective.

Metals

For metals, if mild detergent solutions have no effect, use a heavy duty detergent or dilute sulphuric acid; or for stainless steel a mild proprietary abrasive cream is usually very effective.

Paintwork

For paintwork, a detergent in water should usually suffice. If this proves unsuccessful, a gel type paint stripper should be used.

Floors

For cleaning PVC floorcoverings, the protective emulsion coating that these floors should have can be removed with hot water. If hot water or a detergent cleaner does not remove the contamination, then the affected parts may have to be replaced.

For cleaning other floorcoverings, which have a waxed surface coating, use a suitable solvent to remove this protective layer, and hopefully the contamination will be removed. If not, the floorcovering may have to be

replaced.

Varnished bench tops can be cleaned as for paintwork, and formica bench tops can be washed with the proprietary cleaning solutions, or if necessary, a mild abrasive cream can be used.

‘Corian’ benchtops can even be rubbed down with ‘wet & dry’ emery paper.

Benchtops

Dealing with PPE

Disposable gloves, sleeves or aprons which become contaminated, can be disposed of with the radioactive waste, and there is no problem. However, if one’s laboratory coat becomes contaminated, the contaminated area should be washed with a proprietary detergent in the laboratory before sending it to the laundry, or it may need to be left in a safe place for the activity to decay, or it may be discarded as radioactive waste.

On no account must contaminated clothing be sent to the laundry.

Personal decontamination

For all personal contamination, the possible need to seek medical advice should be borne in mind.

For contamination of the skin, e.g. arms, hands etc., the first step is to wash the affected area with soap and water, as normal. If the contamination persists, it should be washed and scrubbed gently, using a soft brush, with a deep cleansing soft soap or liquid soap, such as 'Clearasil' or 'Dermactyl'. Care must be taken not to break the skin.

If the contamination persists after several wash and scrub treatments and the contamination is restricted to parts of the hands, these may be cleansed with a saturated potassium permanganate solution. This will remove a superficial layer of skin, and care must be taken to ensure that no undissolved crystals are present. The brown discoloration left by the permanganate can be removed with a 10% solution of sodium metabisulphate. If any other parts of the body are contaminated and the contaminant is not easily removed by ordinary washing then specialist help should be obtained.

If serious injury, cuts and wounds are associated with the contamination, these should be irrigated and first aid measures taken before dealing with the contamination. Body openings, such as eyes, ears, nose and mouth should always be decontaminated first. Decontamination of any 'hot spots' on other parts of the body should be dealt with next. Care should be taken to ensure that washings do not contaminate other areas. If the casualty has to go to hospital for treatment of wounds, only superficial contamination should be removed as a first aid measure.

Emergency showers are rarely the best solution for dealing with a contaminated person as this can spread the contamination. For hand arm and head contamination it is better to use a hand wash basin and for legs a footbath.

Appendix 3 - MODELS FOR DESIGNATING AREAS

Model A *(see Ref E10)*	**Designation in relation to the Internal Hazard**
NRPB M443 Categorisation and Designation of Working Areas in which Unsealed Radioactive Materials are used. (*Ref E3)*	NRPB have looked at this problem in document M443. They looked at a variety of operational scenarios and exposure pathways to calculate the maximum quantity of different isotopes that could be handled in different grades of laboratory consistent with dose constraints of either 1mSv or 5mSv. They recommended that all areas where the dose constraint for the internal hazard is greater than 1mSv should be designated as controlled areas. A higher grade facility has a lower risk of inhalation/ingestion and contamination and therefore a larger quantity is permitted to be handled for the same dose constraint. Under this model the quantities permitted are large by university standards. It is therefore practical for us to work to a lower dose constraint that would also have the advantage of not requiring biological monitoring. It is recommended that we work to a dose constraint of 0.2mSv for the internal hazard using the NRPB model and this would permit the following quantities to be used in Grade 'C' and Grade 'B' laboratories:- Grade 'C' - non-volatile work -up to 120 ALIs - volatile in fume cupboard -up to 30 ALIs Grade 'B' - non-volatile work -up to 1200 ALIs - volatile in fume cupboard -up to 300 ALIs
Grade ‘C’ is a general chemical laboratory. Grade ‘B’ is a higher grade facility usually with an ante-room or lobby for washing and changing. See Appendix 4 for information on laboratory design	ICRP68 recommends the use of the dose coefficient e(50) which corresponds to the committed effective dose E(50) resulting from an intake of 1Bq of the radionuclide. Therefore an annual limit of intake can be calculated for the annual dose limit of 20mSv using the following formula:- 1 ALI = $\frac{0.02}{\text{annual dose limit (Sv)}}$ e(50) dose coefficient (Sv/Bq)
ICRP 68 Dose coefficients for intake of radionuclides by workers. (*Ref C2)*	Using the most restrictive dose coefficients for inhalation or ingestion the following activities for the common radionuclides used in universities have been calculated and are given in Table 1 below.

Table 1 - ALIs/Activities for the Common Radionuclides

Radionuclide	**1 ALI**	**30 ALI**	**120 ALI**	**300 ALI**	**1200 ALI**

	H-3 (water)	1.1 GBq	33 GBq	132 GBq	330 GBq	1320 GBq
	H-3 (OBT)	470 MBq	14 GBq	56 GBq	140 GBq	560 GBq
	C-14	34 MBq	1 GBq	4 GBq	10 GBq	40 GBq
	S-35	15 MBq	450 MBq	1.8 GBq	4.5 GBq	18 GBq
	P-32	6.2 MBq	186 MBq	744 MBq	1.9 GBq	7.4 GBq
	P-33	14 MBq	420 MBq	1.7 GBq	4.2 GBq	17 GBq
	I-125	1.3 MBq	39 MBq	156 MBq	390 MBq	1.6 GBq
	Cr-51	530 MBq	16 GBq	64 GBq	160 GBq	640 GBq

	For those radionuclides where the external hazard is low the above figures can be taken as the limits that are recommended for supervised areas in the given grade of facility.
	Designation where there are both internal and external hazards
	Where radionuclides present both an internal and an external hazard then a realistic assessment should be made of the likely doses that will result from the proposed work and every effort must be made to reduce these by the use of appropriate shielding. Working to an internal dose constraint of 0.2mSv, it will be the control of the external hazard, and whether special procedures are required to ensure this, that will determine the need, or otherwise, for a controlled area. For example with P-32 lower limits than those specified above will have to be employed for supervised areas. At Sheffield University 12 ALIs for a Grade C lab and 120 ALIs for a grade B lab have been used.
	Designation where female workers are involved
ICRP 88 Doses to the Embryo and Fetus from Intakes of Radionuclides by the Mother (*Ref C9*) See also HSE Contract Research Report 397/2001 (*Ref A21*)	Recent studies have indicated that in some circumstances when working with unsealed sources the foetus can receive a higher dose than the mother following an intake of radionuclide. This preferential uptake is most pronounced with the bone building elements of phosphorous and calcium. Working to an internal dose constraint of 0.2mSv in our model allows an increased dose factor of 5 for the foetus without breaching the 1mSv dose constraint of IRR99 Reg 8(5). This will accommodate all radionuclides except the phosphorous and calcium radionuclides. The highest increased dose factors associated with these radionuclides are given in the table below:- **Radionuclide Pathway Increased dose factor** P-32 inhalation x 17 at 35 weeks x 13 during term of pregnancy P-32 ingestion x 14 at 35 weeks

	x 10 during term of pregnancy P-33 inhalation x 23 at 25 weeks x 19 during term of pregnancy P-33 ingestion x 25 at 25 weeks x 20 during term of pregnancy Ca-45 ingestion x 16 at 25 weeks x 11 during term of pregnancy Ca-47 ingestion x 6.3 at 35 weeks x 4.8 during term of pregnancy If one took the highest factor from the above table (25 for P-33) and used it for all the phosphorus and calcium radionuclides, one would need to work to a dose constraint from the internal hazard to the mother of 0.04mSv in order to comfortably meet the constraint to the foetus of 1mSv. In our model, for work with non-volatile radionuclides, this would mean working to a limit of 24 ALIs in a Grade 'C' laboratory and 240 ALIs in a Grade 'B' laboratory. This is still a considerable amount of activity and for penetrating radiations control of the external hazard may still be the overriding factor, e.g. the use of 12 ALIs for P-32 in a Grade 'C' lab (see above). Therefore it should still be possible to choose a maximum working level for a supervised area that will satisfy the dose constraint for the foetus whilst not discriminating against women workers.

Model B: Designation as a consequence of management control systems

used in the pharmaceutical industry. *(see Ref E8)*

The threshold activities for common radionuclides suggested for Supervised Area designation in model A are large when compared with activities routinely used in pharmaceutical industry research laboratories.

The pharmaceutical sector has applied what is in essence a risk assessment/management control philosophy to its designation of laboratories. This philosophy is quite simple and can be summarised as follows.

1. All work with ionising radiations must be subject to local rules or working procedures, have compliance with IRR99 secured by local radiation protection supervisors (RPS) and line management, and if appropriate be subject to additional written arrangements.

1. High-risk activities using ionising radiations must be conducted in suitable, segregated facilities where engineering controls are sufficient to minimise risk of both internal and external contamination/exposure.

1. Suitable personal dosimetry and area contamination monitoring procedures will be in place to confirm the efficacy of local control measures.

1. All areas where ionising radiations are used will be subject to periodic inspection/audit to further confirm efficacy of local control measures.

In general five main types of activity are carried out with ionising radiations in pharmaceutical research laboratories and this forms the basis for an area designation regime.

1. Radiosynthetic areas where drug materials labelled with ^{14}C or ^{3}H are prepared for subsequent use in metabolic and other studies.

1. Radioiodination facilities.

1. Areas for storage and primary dispensing of stock solutions, or for the use of relatively high levels of radioactivity.

1. General biological/biomedical work areas.

1. Areas where x-ray equipment is used for various applications (usually either analytical or biomedical/veterinary) or where large gamma irradiation units (often containing TBqs ^{137}Cs) are housed.

Type 1 and 2 areas generally have very high standards of furnishings, finishings and well-maintained engineering controls and are equivalent to grade II facilities detailed in NRPB M443. Typically, such facilities will be dedicated to work with radioactive materials and thus be subject to strict access control procedures. Workers may be subject to bioassay monitoring (urine analysis and thyroid monitoring respectively). Type 1 and 2 areas will usually be designed as, or contain either Controlled or perhaps Supervised Areas, to reflect both the higher level of risk of the work undertaken therein and also the engineering and procedural control measures in place to regulate usage of such facilities

Type 3 areas are used for storage and initial dispensing of ^{125}I (for non-iodination applications) commercial stock solutions, usually containing ^{32}P, ^{33}P, ^{35}S, ^{14}C or ^{3}H, and also for some classes of work with relatively large amounts of radioactivity. Such facilities will often be dedicated to these functions; aliquoted materials will be suitably contained and then typically may be taken to a Type 4 area for routine usage. Access control to these facilities clearly reduces the number of workers potentially exposed to large activities and permits the provision of appropriate shielding and handling equipment to minimise the high local external doses that could be received from handling stocks of ^{32}P or ^{125}I. Workers using these facilities may be subject to routine personal dosimetry [body or extremity dosimeters]. These facilities may be designated as Supervised (or perhaps Controlled) Areas. Another feature of this regime is that it tends to centralise stocks of radioactive materials thus simplifying

some of the administrative burdens inherent in the Radioactive Substances Act 1993 stock control requirements.

Type 4 areas are used for a wide range of biomedical/biological work, including manipulations of low levels of radioactivity. The general design criteria for such areas is again high, generally being equivalent to Advisory Committee on Dangerous Pathogens Containment Level 2 [ACDP2] requirements. These facilities need receive no specific designation under IRR99, although work procedures may require some designation [eg 'tracer' or 'registered' area] and local signage will warn that there is the limited use therein of radioactive materials.

The designation of Type 5 areas, containing either x-ray equipment or irradiation facilities, is dependent upon the nature of the equipment/work undertaken. Certain applications may require no specific designations (XRF machines etc) whereas other activities such as the open use of high powered x-ray machines will certainly require the designation of a local Controlled Radiation Area with concomitant stringent access/engineering/procedural control measures.

Irradiation units, suitably manufactured interlocked and type tested may not require a specific area designation for their location from a purely radiation protection perspective. However access controls to such facilities are often introduced, partially as a security measure and also to ensure that persons using such facilities receive suitable instruction and training.

Typical minimum activity thresholds *in relation to the internal hazard* are presented in

Table 2.

These limits are based on the lowest Annual Limits on Intake (ALI) (ingestion or inhalation) given in ICRP 68 (Ref C2) and use an activity threshold of 3 ALI for Supervised Area designation and 10 ALI for Controlled Area designation. These limits are significantly lower than those proposed in Models A; given the levels of procedural, engineering and management control outlined above, individual worker dose consequences from working in any category of pharmaceutical research laboratory are minimised. These limits provide a sound and conservative basis for dose minimisation and management control of applications of ionising radiations within the pharmaceutical industry, and furthermore, they serve to minimise the possibility of the spread of radioactive contamination and subsequent cross contamination of experiments. *These activity thresholds do not take account of external radiation dose and where appropriate (eg for P-32) additional risk assessments may need to be undertaken to determine minimum activity thresholds in relation to the external hazard.*

Table 2

| | **Supervised Area Minimum Activity Threshold (Bq)** | **Controlled Area Minimum Activity Threshold (Bq) *(10***

	(3ALI)	*ALI)*
H-3 (water)	3.3×10^{9}	1.1×10^{10}
H-3 (OBT)	1.4×10^{9}	4.7×10^{9}
C-14 compounds	1.0×10^{8}	3.4×10^{8}
P-32 compounds	1.9×10^{7}	6.2×10^{7}
P-33 compounds	4.2×10^{7}	1.4×10^{8}
S-35 organic compounds	7.8×10^{7}	2.6×10^{8}
I-125 compounds	3.9×10^{6}	1.3×10^{7}

Appendix 4 - LABORATORY DESIGN

The Environment Agency has produced guidance applicable to laboratories in teaching and research establishments and this is reproduced below. This guidance should be borne in mind when designing new facilities. The main criteria to be met is that -

'the floor, ceiling, walls, furniture and fittings in any part of the premises where a registered substance is used are maintained in such a condition that they can be easily cleaned.'

This requirement for surface finishes which can be easily cleaned is now stipulated in the regulations for the use of other hazardous substances as well (*see Ref E7*). Surfaces should be impervious to water and offer resistance to acids, alkalis, solvents and disinfectants.

Some aspects of laboratory design have not been fully covered in the EA Guidance or alternatives are to be recommended and these are summarised as follows :-

Floor coverings - should have minimum number of joins, full coving is recommended for higher grade areas but coved skirting which seals the gap between floor and wall may be adequate and more economical for many areas.

Walls and ceilings - painting with vinyl emulsion is not recommended. Acrylic emulsion provides a much harder more durable surface and for higher-grade labs oil-based paints, either in eggshell or gloss give a hard surface that is easily cleaned without surface damage.

Wash-hand basin - taps should be of a type that can be operated without being touched by hand (e.g. knee operated ones or ones utilising optical sensors).

Changing facilities - as a minimum, somewhere to hang lab coats should be provided near the entrance to the laboratory. It is usual to provide a lobby/changing area for higher grade laboratories.

Fume cupboards - if a fume cupboard is to be used for containment when working with substantial quantities of a hard gamma emitter then the plinth will need to support a considerable amount of lead shielding (possibly up to 1,000 kg).

Seating - stools and chairs should either be non-upholstered or upholstered in non-absorbent material.

Environment Agency - Guidance on standards for radiochemical laboratories

in non-nuclear premises

1. Introduction

1.1 This Note provides guidance to Inspectors on the key considerations, from the Agency's perspective, for laboratory facilities on premises where "open" radioactive sources are kept and used.

1.2 This Note focuses on radioactive waste management implications. It does not specifically cover radiation safety and the protection of workers on premises, which may give rise to additional requirements such as radiation shielding. However, nothing in this Note should conflict with occupational radiation safety considerations, e.g. those in the Ionising Radiations Regulations 1985. As the matters dealt with in this note are of common interest to the Agency and HSE, Inspectors should consider liaising with colleagues in HSE on specific cases.

1.3 By its very nature, any use of open sources is dispersive to some extent, and there will inevitably be arisings of radioactive wastes that will need to be managed. There is a requirement to ensure that any radioactive waste which is generated is of such a type and quantity that it can be disposed of by an available route, and to prevent any disposal of radioactive waste by an unauthorised route. Additionally, in accordance with Government policy on waste minimisation, the Certificates of Registration issued by the Agency under the Radioactive Substances Act 1993 require that, so far as is reasonably practicable:

a. the amounts of radioactive waste that do arise are minimised; and

b. all relevant parts of the premises are constructed, maintained and used in such a manner that they do not readily become contaminated, and that any contamination which does occur can easily be removed.

1.4 The purpose of this Note is to expand on those requirements so as to provide guidance on the standards which users are expected to apply. This is neither prescriptive nor exclusive, and there may be other appropriate means of compliance in specific circumstances. Clearly this Note is not a detailed design guide, and users should be expected to consult relevant publications on laboratory design and to take advice before constructing a new radiochemical laboratory.

1.5 The benchmark for the standards given in this Note is a new radiochemical laboratory. Inspectors should always have regard to the criterion of reasonable practicability; therefore it may not be appropriate to impose these standards where any of the following are involved: existing facilities; or holdings only of the less-radiotoxic nuclides such as tritium or carbon-14; or minor usage, such as a few radioimmunoassay kits; or "one-off" (as opposed to continuing) uses.

1.6 Specific guidance has been produced by the National Radiological Protection Board on the categorisation and designation of radiochemical laboratories (Ref 1). It should be noted that the categories and associated facilities are based on occupational radiation exposures, rather than waste minimisation principles, and a proposal involving the facilities indicated by NRPB Categories IV and V may need particular scrutiny from the Agency's perspective. Nevertheless they are a useful indication of what may be expected at various levels of work. The Association of the British Pharmaceutical Industry has also published specific guidelines for that industry (Ref 2).

1.7 In the following sections, extensive use has been made of points contributed by user organisations (Refs 3, 4) which are acknowledged with thanks.

2. Floors

2.1 The floor should be covered with an impervious surface such as a **continuous** sheet of PVC or linoleum at least 2.5 mm thick. The covering should be coved to the walls to a height of about 15 cm contiguous with the floor surface. All edges at the walls should be sealed or welded to prevent seepage of spilled materials.

2.2 Joints between sheets are not recommended, but may be permitted if the joints are welded and inspected to ensure the absence of a seepage path for contamination.

2.3 Any non-slip sealant material used to facilitate cleaning may be applied provided that spilled materials can be easily removed during the decontamination procedure. Generally, epoxy resin coatings are easily decontaminated.

2.4 As an alternative to a sheet material covering (such as PVC), an epoxy resin coating may provide an acceptable finish on smooth concrete.

3. Walls and Ceilings

3.1 The walls and ceilings should generally be smooth and painted with a hard gloss or high quality waterproof vinyl emulsion to facilitate cleaning. (B S 4247 Part 2). The use of stippled surfaces or a paint finish applied to unplastered concrete blocks, may be undesirable.

3.2 A note of caution: many paints undergo chemical or physical reactions with certain radionuclides. A more important criterion may therefore be the ease with which the paint can be stripped off again rather than its cleaning properties. A

known problem occurs with chloride ions which may bind irremovably with painted surfaces.

3.3 Suspended ceilings may potentially cause problems due to penetration of contamination.

3.4 Joints should be sealed or filled with silicone type materials to facilitate cleaning (or removal in the event that decontamination cannot be achieved). Service penetrations in walls and ceilings should be sealed and coved.

4. Doors and Windows

4.1 Wooden surfaces should be covered with plastic laminate material or painted with a good quality polyurethane gloss paint or varnish. See 3.1 and 3.2 above.

4.2 Security of keeping radioactive materials is essential and therefore doors should usually be lockable to ensure safe keeping or to restrict access in the event of major spillage of the materials. Doors leading off public places and which are frequently opened may additionally be secured by use of a key pad lock. For some sites, for example in the pharmaceutical industry, the user may provide a high level of security for a building and/or an entire site, rather than for an individual laboratory within a building.

4.3 Where opening windows are fitted, care should be taken that no persons will be affected by any release of radioactivity immediately outside. Open windows should not be used as intentional discharge routes.

5. Benches

5.1 Working surfaces should be smooth, hard and non-absorbent and have necessary heat and chemical resistant properties. All gaps and joints should be sealed with a silicone type material. Depending on the type and quantity or radioactive materials used, account may need to be taken of the problems involved in decontaminating certain materials used for bench surfaces. For example: "Corian" apparently locks onto iodine (e.g. I- 125) in several chemical forms; Melamine fixes sodium ions (e.g.Na-22) under some conditions; stainless steels may bind phosphate (e.g.P-32) or chromium (e.g. Cr-51) firmly and may be very difficult to decontaminate (Ref 4).

5.2 The benchtops should be coved (upstand) at the rear against walls. Gaps should be sealed with a silicone type material. Benchtops may also have rounded front edges (lipped) so as to give fewer entry points for contamination - although some users feel this increases the likelihood of spills on to the floor, as the operator may misjudge where the flat surface of the bench finishes. Some bench top designs have a raised front lip which can help prevent a spillage running off the bench on to the floor.

5.3 Exposed wood, including under benches and under bench cupboards, should be painted with a good quality hard gloss paint or polyurethane varnish or laminated. The use of wood surfaces should be avoided on all <u>new</u> laboratory designs.

5.4 Users should carry out inspections to ensure that cracked surfaces are repaired or painted as appropriate.

5.5 Dedicated areas of bench should be set aside for radioactive work and be clearly delineated. It is good working practice to work in plastic or metal trays on bench tops - and, especially, in dispensing / preparation cabinets where larger quantities of activity are involved - to minimise spills and spread of contamination. Disposable absorbent coverings such as "Benchkote" may similarly be useful - but as a supplement to, rather than instead of, proper bench surfaces: these coverings may therefore best be used inside trays.

6. Waste Disposal Sinks and Drainage Pipes

6.1 Sinks for the disposal of radioactively contaminated aqueous liquid waste should be constructed of suitable material: for most applications, stainless steel is preferred. Where possible, combined sinks and draining boards should be used, with rounded front edges and coved (upstand) at the rear against walls. Ideally an easily decontaminable rear splash plate should extend a reasonable distance up the wall behind the sink. Side splash guards may also be useful.

6.2 As noted in 5.1 above, phosphate ions may bind strongly on to stainless steel, and this may cause problems in laboratories where P-32 is used in quantity. (Similar problems may arise where old fashioned sinks have been sealed with putty or in hard water areas where a calcium phosphate layer may be precipitated in the sink). Borosilicate glass sanitary ware may be appropriate in some circumstances.

6.3 Small diameter U-shaped or bottle traps should be used, instead of large traps or catch pots, so as to avoid accumulations of radioactive sediments.

6.4 The drain should be connected as directly as possible to the main foul water sewer leaving the premises. Holding tanks are generally undesirable in terms of sedimentation, but may be used by some industries for other reasons - such as confirming compliance with chemical discharge consent conditions. The discharge route should be mapped and recorded for future reference in case of maintenance on the system. Drainage system materials should take into account the possible build up of contamination on surfaces. **NB.** All drainpipe materials may retain specific radionuclides. The most generally useful type - "vulcathene" fixes iodine very strongly - which may be significant where the radioiodines have to be disposed of through drains of this material.

6.5 Drainage pipes for radioactive effluent should be labelled with the ionising radiation symbol up to a point at which their contents are diluted substantially with frequently - flowing, non-radioactive effluents. This is to alert maintenance staff and thus prevent unauthorised disposal of any contaminated pipes removed during maintenance work. Pipes should be well-supported along a suspended run, should be down-sloped to prevent accumulations of radioactivity, and, where reasonably practicable, should be made accessible - for example by the use of demountable panels - and subject to periodic inspection so as to assure their integrity.

7. Ventilation and Containment

7.1 Dispensing or preparation of radioactive materials which may cause airborne contamination should be carried out under conditions to prevent dispersal of the substances. In particular, volatile radioactive materials should never be used in the open laboratory, only in appropriate containment such as a fume cupboard. Recirculating ventilation systems may be inappropriate for volatile radioactive materials.

7.2 General dilution ventilation (air circulation) should be provided in all radioactive laboratories. Where small quantities of radioactive materials are used, this may be provided using an extractor fan mounted in a window or a wall.

7.3 Where larger quantities of radioactive materials are used, a guiding principle for effective control of contamination is that air movement should be maintained from less-contaminated areas to more-contaminated areas. This may be achieved for example by extracting from a general laboratory area through a fume cupboard to a discharge stack.

7.4 Inspectors should note that the balancing of an extract ventilation system having a number of ducts, dampers and inlet points, so as to achieve design airflow rates, requires considerable skill and expertise. Alterations to damper settings by unskilled operators are therefore generally to be deprecated.

7.5 A contained work station (Class I - III microbiological safety cabinet or fume cupboard) should be used for dispensing or manipulation of large quantities of radioactive materials. Adequate ventilation by continuous movement of air into the work station should be checked regularly, preferably by measurement with an anemometer. Airflow criteria for fume cupboards are specified in BS 7258.

7.6 Internal and external surfaces should be smooth, hard and non-absorbent and have the necessary heat and chemical resistant properties.

8. Radioactive Storage Facilities (Including Waste)

8.1 Adequate storage space should be available to keep essential equipment in order to minimise the cluttering of equipment near working areas, and reduce the risk of spreading contamination. It may be desirable to have an area set aside for the storage of equipment awaiting decontamination.

8.2 All refrigerators / freezers, and radioactive materials within them, should be easily identified (labelled) and should be lockable and should be kept locked unless they are under surveillance, especially in large general laboratories. Refrigerators / freezers should be regularly defrosted. It should be noted that volatile radionuclides, in particular tritium, may accumulate in the ice: it is good practice for the user to check this periodically.

8.3 Waste disposal bins in the laboratory (used for storing solid waste awaiting disposal) should be constructed of a material which is robust, and preferably should be foot-operated. The lid should be closed when not in use and the contents in the bag sealed or secured before removing them from the bin. All sharps, bottles, tubes, etc should be placed in sharps containers to ensure safe handling of the, materials. Bins located outside the control of the user must be secure to prevent misuse of the contents.

8.4 Adequate storage space (eg. a bunker or store room) should be available for radioactive waste either inside or outside the laboratory. The storage space must be kept locked and may need to be under surveillance.

9. Other Facilities

9.1 Adequate **decontamination facilities,** including decontamination solutions, should be available. "Decon" (and "Radiacwash", "Countoff' etc.) is principally useful where heavy metal contamination is present, as its special properties are in solubilising poorly soluble metals. In other circumstances, its performance may be similar to other phosphate free detergents. For most labs only the ordinary detergent used for washing up and liquid soap for hand washing should be needed, although certain other more specialist cleaning agents may be used for special purposes. It is important that some of the old-fashioned laboratory cleaning agents such as chromic acid and permanganic acid are never used in radioactive areas (risks of fire, explosion and volatilisation of radioactive materials). More aggressive decontamination agents should normally be held centrally as they require specialised knowledge to use them properly and safely.

9.2 A **contamination monitor** should be available and it must be appropriate for the type of radionuclides used in the laboratory. Indirect monitoring (by liquid scintillation counting of swabs taken from surfaces) may be needed for soft beta emitters such as carbon- 14 and (almost always) tritium. Records demonstrating that instruments are checked before use and are calibrated are required. A log book should be available to show that the laboratory is regularly monitored (benches, sinks, floors, drainage traps and equipment), that the results are recorded, and that any necessary decontamination is carried out.

9.3 **Tacky mats** may usefully be installed in laboratory doorways, to prevent the spread of contamination. Monitoring of these mats may give early warning of a contamination problem.

9.4 A designated **hand wash basin** should be provided: it must never be used for the disposal of radioactive substances (other than traces from the washing of hands).

9.5 **Warning signs**, clearly and legibly marked with the word "Radioactive", with the Ionising Radiation symbol conforming with BS3510: 1968 or ISO 36 1, and any other information necessary (contact person, telephone number, etc), should be placed on doors, cupboards, equipment, refrigerators, working areas, drainage pipes, sinks, storage facilities, sewers, exhausts as appropriate. An indication of the maximum holdings in the laboratory may usefully be included on the sign placed on the door. Warning signs should only be used when there is a real possibility of contamination: in particular, indiscriminate use of "radioactive" warning tape should be avoided. Generally, ancillary items such as pens and books should not be used where there is a possibility of contamination and therefore should not require warning signs.

9.5 Adequate **lighting** should be provided throughout the laboratory, particularly to enable operators to see spillages easily.

9.6 Particular considerations apply to users who handle **tritium in quantity.** Although this is a rather specialised field affecting relatively few users, nevertheless Inspectors may find it useful to be aware that tritium may be readily converted to tritiated water, which when allowed into the working environment moves with atmospheric water vapour. It is taken up by most common

materials - wood, paper, clothing - and this can make them impossible to decontaminate. It is the usual practice for a facility handling large amounts of tritium to be separate from other buildings to prevent the spread of radioactivity beyond the controlled area, and to allow any escape to be diluted by the outside atmosphere.

References

1 A P Hudson and J Shaw, 1993. Categorisation and Designation of Working Areas in which unsealed Radioactive Materials are Used. National Radiological Protection Board Memorandum NRPB - M443.

2. Association of the British Pharmaceutical Industry, 1996. Guidelines on the Control of Radioactive Substances in the Pharmaceutical Industry. Published by the ABPI, 12 Whitehall, London SW1A 2DY).

3. South Birmingham Area Health Authority, Personal Communication.

4. D Walland, University of Bristol, Personal Communication.

Radioactive Substances Developments Group, Environment Agency, December 1997

Appendix 5 - EXAMPLES OF TRAINING RECORDS

(See Ref E10)

Record of Training in Radiation Protection

Name :.....……

Department : .....…….

Personal Registration issued on .....

Dates of completion of training:

a) Departmental training - Departmental Procedures .....

- Training by Academic/Section Supervisor .....

b) Obligatory lecture by Safety Services .....

c) Other relevant courses attended (specify below):

Authorisation from Safety Services has been granted for use of :-

(list isotopes or whether X-rays or neutrons) .....

covered by the following Work Certificates: .....

Radiation Worker's Acknowledgement

I am aware of the hazards associated with my work and the care that needs to be taken when working with ionising radiations. I have been trained in (or I am familiar with) the techniques and procedures associated with my planned work and will undertake such further training as is necessary (see below). I am aware of the departmental procedures associated with record keeping and the management of isotope stocks and waste (*if appropriate*). I have read the appropriate sections of the University's Local Rules and am aware of my duties and responsibilities under the Ionising Radiations Regulations 1999 and the Radioactive Substances Act 1993 (*if appropriate*).

Further training required in:.....…

.....
.....

Signed:..... Date: .....

Important Note: Please inform your Radiation Protection Supervisor (RPS) when you have received training from your academic/section supervisor and are in a position to sign the declaration and commence work with ionising radiations.

This record, together with certificates of attendance and course details, must be kept safely and must be available for inspection at any time by your RPS, Safety Services or external inspectors.

Introduction to Departmental Procedures -work with radioactive materials

Department of.....

Name: .....

This forms part of the statutory requirement for training in radiation protection. Please initial those items covered and indicate 'n/a' for those items not applicable.

Requirements for Registration of Work Certificates	
Requirements for Registration of Laboratories	
Departmental procedures for ordering and receiving of isotopes	
Storage of isotopes	
Completion of Isotope Record Sheets	
Disposal of wastes - including all relevant disposal limits	
Monitoring of work areas	
Use of TLD badges - how to wear and procedures for exchange	
Use of finger dosimeters - issue of, how to wear, and return of.	

Notes:

The above named person has received a brief introduction to departmental procedures.

Signed: .....

Name (PRINT) : .....

Date …… (RPS or person authorised by RPS)

Date : .....

Training by Academic Supervisor

Department of .....

Name: .....

The above named person has received appropriate training or has demonstrated appropriate knowledge in the following laboratory techniques and precautions required for the handling of radioisotopes during experiments for which I am the academic responsible.

(Please initial those items covered and indicate n/a for those items not applicable

Use of the Work Certificates applicable in my laboratories. The Work Certificates that are applicable have been explained, emphasising the limitations of where the work can be done and what isotopes/chemicals can be used. The procedure for making amendments to Certificates has been indicated.	
Organisation of isotope work in my laboratories The areas of my laboratories that are designated for use with isotopes have been indicated. Procedures for receipt of isotopes delivered to my laboratory, and safe storage in designated store (location must be marked on isotope record sheet). The use of Benchkote to protect benches from spillage and the marking of designated areas with radioactive tape. Steps to avoid spread of radioactive contamination and the system for separation of contaminated glassware from general washing up have been shown.	
Completion of isotope record sheets (if not covered by RPS) How to complete the Isotope Record Sheets accurately, and account for decay and disposal of radioactive materials. What to do if material is received from or sent to other Establishments (if that is likely within your research group).	
Calculation of radioactive decay (if applicable) Methods for correction for radioactive decay of the isotopes that are used by my group, and how to use this in completion of Record Forms	
Monitoring procedures and precautions for use with ^{3}H, ^{14}C, ^{32}P, ^{33}P, ^{125}I * other isotopes (specify)..... The necessity of using appropriate methods for monitoring the work area before and after a piece of work, using GM counters or wipe tests, and how to record the results of such monitoring for inspection. Special precautions required for work with the isotopes that the worker will be using - eg use of shielding, gloves, goggles, TLD badge and finger dosimeters at appropriate stages of use and/or dispensing. What to do in case of accidental spillage.	
Precautions for release of gaseous waste How to vent release of radioactive gas safely, and show designated FCs	

Disposal of solid and liquid wastes (including animal waste*) Use of the different bins for disposal of solid wastes with short and long half-lives, how to label them correctly, and how to get them removed from the lab when full. The methods of disposal of liquid wastes - e.g. via a designated sluice, low levels via designated sink. How to dispose of animal carcasses via the macerator (if relevant).	
Door signs, labelling of solutions The meaning of the door signs in my laboratories, the necessity of labelling fridges and other stores where isotopes are stored, the importance of clearly labelling all radioactive materials and solutions with an identifying number so that they can be linked to the Isotope Record Sheet.	
Other techniques (specify):	

(* *delete as appropriate)*

I undertake to provide appropriate additional training as required and to ensure that the above named receives an appropriate level of supervision throughout his/her work in my laboratory.

Academic Supervisor (signed):..... Date: .....

Name (Print) .....

Other person providing training (signed): ..... Date: .....

Name (Print): ..... Position.....

Appendix 6 - EXAMPLE OF WIPE TEST FOR TRITIUM

(See Ref E10)

In order to check for any possible contamination, it is required of the users of tritium to take routine wipe tests. (Because of the low beta energy it is not practicable to detect tritium with a portable monitor.)

Method:

A 6cm Whatman GF/A filter paper (or No.1) is folded to form a small pad. This is then moistened with distilled water, held with tweezers and the area to be tested is then wiped. It is usual to wipe approximately 100 cm^2. This can be done by wiping a 10cm x 10cm square or a straight or random transect of approximately 50cm in length (pad should be approximately 2cm wide). The filter paper is then put in a vial of scintillant that accepts aqueous samples and is ready for counting.

Results

In analysing the results, it is assumed that the wipe test takes 10% of contamination and that 100 cm^2 are sampled.

for 37 Bq/cm^2 one should detect 37 x 0.1 x 100 dps

= 370dps

= 22,000 dpm

A record should be kept of the results of the wipe tests.

Action to be taken on results

a) >220 dpm <22,000 dpm - clean if practical, importance of removal dependent upon nature of work.
(Remember it is important to keep contamination as low as reasonably achievable.)

b) >22,000 dpm - clean as soon as possible and remove as much contamination as reasonably practicable. Look into possibility of other items being contaminated.

Where to Wipe?

The most obvious places are bench tops adjacent to where work took place. Also, anything that could have been accidentally handled, e.g. fridge doors, cupboard fronts, automatic dispensers or pipettes, etc.

How often to Wipe?

This is at the users' discretion, but should be carried out according to the amount and frequency of experiments, e.g. if experiments are once every 3 months, after each experiment has finished would be sufficient, but if the work was continuous for a period of time, then making tests once per week would be more prudent.

When work is in progress in a non-designated area then a minimum of a monthly survey should be performed and in a supervised or controlled area a minimum of a weekly survey should be performed.

If users have any difficulty in removing contamination or require further information on wipe tests or monitoring in general they should contact their RPS/RPO/RPA as appropriate.

Appendix 7 - TABLE OF COMMON RADIONUCLIDES

FROM SCHEDULE 8 OF IRR99

	Regulation 6 and Schedule 1		Regulation 30	
Radionuclide	Concentration for notification	Quantity for notification	Quantity for notification of release or spillage Bq	Quantity for notification of loss or theft Bq
	Bq/g	Bq		
Tritium (OBT)	$1\ 10^{6}$	$1\ 10^{9}$	$1\ 10^{12}$	$1\ 10^{12}$
C-14	$1\ 10^{4}$	$1\ 10^{7}$	$1\ 10^{11}$	$1\ 10^{8}$
C-14 dioxide	$1\ 10^{7}$	$1\ 10^{11}$	$1\ 10^{13}$	$1\ 10^{12}$
Na-22	$1\ 10^{1}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
Na-24	$1\ 10^{1}$	$1\ 10^{5}$	$1\ 10^{11}$	$1\ 10^{6}$
P-32	$1\ 10^{3}$	$1\ 10^{5}$	$1\ 10^{10}$	$1\ 10^{6}$
P-33	$1\ 10^{5}$	$1\ 10^{8}$	$1\ 10^{11}$	$1\ 10^{9}$
S-35	$1\ 10^{5}$	$1\ 10^{8}$	$1\ 10^{11}$	$1\ 10^{9}$
Cl-36	$1\ 10^{4}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
Ca-45	$1\ 10^{4}$	$1\ 10^{7}$	$1\ 10^{10}$	$1\ 10^{8}$
Cr-51	$1\ 10^{3}$	$1\ 10^{7}$	$1\ 10^{12}$	$1\ 10^{8}$
Fe-55	$1\ 10^{4}$	$1\ 10^{6}$	$1\ 10^{11}$	$1\ 10^{7}$
Fe-59	$1\ 10^{1}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
Co-57	$1\ 10^{2}$	$1\ 10^{6}$	$1\ 10^{11}$	$1\ 10^{7}$
Co-60	$1\ 10^{1}$	$1\ 10^{5}$	$1\ 10^{10}$	$1\ 10^{6}$
Ni-63	$1\ 10^{5}$	$1\ 10^{8}$	$1\ 10^{11}$	$1\ 10^{9}$
Zn-65	$1\ 10^{1}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
Rb-86	$1\ 10^{2}$	$1\ 10^{5}$	$1\ 10^{11}$	$1\ 10^{6}$
Sr-90	$1\ 10^{2}$	$1\ 10^{4}$	$1\ 10^{9}$	$1\ 10^{5}$
Tc-99m	$1\ 10^{2}$	$1\ 10^{7}$	$1\ 10^{13}$	$1\ 10^{8}$
Cd-109	$1\ 10^{4}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
In-111	$1\ 10^{2}$	$1\ 10^{6}$	$1\ 10^{11}$	$1\ 10^{7}$

I-125	$1\ 10^{3}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
I-131	$1\ 10^{2}$	$1\ 10^{6}$	$1\ 10^{10}$	$1\ 10^{7}$
Cs-137	$1\ 10^{1}$	$1\ 10^{4}$	$1\ 10^{10}$	$1\ 10^{5}$
Th-232 sec	$1\ 10^{0}$	$1\ 10^{3}$	$1\ 10^{6}$	$1\ 10^{4}$
U-238 sec	$1\ 10^{0}$	$1\ 10^{3}$	$1\ 10^{6}$	$1\ 10^{4}$
Am-241	$1\ 10^{0}$	$1\ 10^{4}$	$1\ 10^{6}$	$1\ 10^{5}$

Appendix 8 – BIOLOGICAL MONITORING

(See Ref E13)

The simple, non-specialist biological monitoring that can be undertaken by most establishments is normally thyroid monitoring for I-125 and liquid scintillation counting for H-3, C-14 and other beta emitters. Other types of monitoring may require specialist equipment (eg whole body counting for gamma emitters and sample oxidisers for faecal samples) which is often unavailable to many establishments.

NB The use of an Approved Dosimetry Service is required for assessing intakes of radionuclides by classified workers.

Thyroid monitoring for I-125

Most ingested I-125 is accumulated in the thyroid within hours of the intake. As the thyroid is close to the neck surface and most low energy gamma contamination monitors (eg Mini Instruments 900/ 44A) are highly sensitive to I-125, the detection of very low levels of I-125 ingestion is relatively simple. The probe from the monitor should be held close to the thyroid (just below the chin) and a reading taken. If possible, the reading should be compared to one taken before the potential ingestion.

For example, a Mini-Instruments 900/44A monitor with the probe placed on the surface of the neck over one lobe of the thyroid gives a reading of ca 40 cps (above background) if the thyroid contains ~ 1.85 kBq I-125. 1.85 kBq I-125 will give rise to a dose to the thyroid of ~ 2 mSv (0.4% of dose limit) and may be used as an action level for a more accurate assessment.

Liquid scintillation counting for betas

The ingestion of H-3, C-14 and other beta emitters may be detectable in the urine and is often used to monitor workers handling relatively high levels (eg > 10 ALI) of these radionuclides. It is best if a 24 hour urine sample can be collected. A 1ml aliquot of this can then be analysed with the radioactive content measured using calibrated liquid scintillation counting techniques, which are available in most establishments. Normally, the monitoring should be part of a pre-arranged monitoring programme as it is important to determine the radioactive baseline for an individual before they handle significant levels of the radionuclides. The relationship between the urinary radioactivity level and the amount of radioactive material ingested depends on many factors, including the route of ingestion and the type of compound involved. An

example action level of 200 dpm.cm-3 (3 Bq.cm-3) above the baseline level could indicate an intake of several kBq of radioactivity.

It should be noted that the above simple methods only give an approximate guide to radioactivity levels and should not be regarded as fulfilling the dose assessment requirements of Reg 21 of the IRR99.

A more detailed consideration of biological monitoring can be found in IAEA Safety Reports Series No.18 on Indirect Methods for Assessing Intakes of Radionuclides causing Occupational Exposure (Ref C7). This includes practical examples of undertaking assessments for a wide range of alpha, beta and gamma emitting radionuclides.

A useful guide on direct methods for measuring radionuclides in the human body is given in IAEA Safety Series no.114 (Ref C8).

Appendix 9 - RADIOLOGICAL COMPLIANCE AUDIT CHECK-LIST

(see Ref E9)

no.	Item –Records RSA93 & IRR99 Compliance	Compliance standard Adequate	Below
1	Check current dept stocks against agreed dept holdings on IsoStock.		
2	Check 3 random isotope receipts with Isostock entries.		
3	Have all Users been issued with copy of Local Rules – inspect file of signed declarations?		
4	Check training of dept Users – DRPO list of Users in Dept?		
5	Check training of the DRPO – records		
6	Check dose records from TLD's and finger stalls – NRPB		
7	Check leak test records on sealed sources (every 2 years)		
8	Transportation - does the method for transport of samples off site comply with the site standard?		
9	Contamination records - do these demonstrate safe working practices?		
10	Does this monitoring cover benches, equipment, floors, taps, sinks, door handles, fridge handles, plastic waste bins, fume-hood and safety cabinet sash handles and		

	washable glass items?		
11	Do hazard/risk assessments show that accidents do not result in unacceptable personal doses, particularly to females of child-bearing age?		
12	Do dose assessment records ‘Smart-Ion’ demonstrate safe working?		

	Item – Facility Audit of Area		
13	Check location of registered sealed sources in dept against official list.		
14	Are liquid wastes stored with adequate absorbent in plastic waste bins that are properly labelled?		
15	Are wastes being properly bagged within plastic waste bins?		
16	Are the time limits on lab storage of medibins complied with?		
17	Are labels contents cards being properly attached and completed?		
18	Have work areas been properly designated, delineated and access restricted?		
19	Unsealed source storage containers/security/labelling are these suitable?		
20	Inter-department transportation - does the method comply with the site standard?		
21	Are adequate containment (trays, etc) employed in the work area?		
22	Are adequate shields provided in the work area?		
23	Where volatile isotopes are handled are sufficient ventilated enclosures provided?		
24	Are these above three measures used by the Users?		
25	Do staff frequently use the contamination monitors provided?		

26	Are the correct type of shields used for the different radiation hazards?		
27	Are personal hygiene rules observed – drinking, eating, chewing, etc?		

Record of Unsatisfactory Compliance (maximum of 5 issues)

Remedial Actions required	Line Manager	By date

I agree with the above recommendations and to ensure their implementation within the suggested timescales.

Signed by:

DRPO:

Date:

Line Manager(s):
Date:

Date:

Dept Manager:
Date:

Radiological Management Committee Review:

Audit report presented to RMC - Date:

Further RMC Comment/Close

NB Copy to be retained by the Department Radiological Protection Officer

Appendix 10 - SURFACE CONTAMINATION ACTION LEVELS

(see Ref E10)

All contamination should be kept as low as reasonably achievable. Action levels should be set above which contamination levels are deemed unacceptable. Two approaches to this have been used in the past: NRPB DL2 approach based upon worst case scenarios that could result in the dose limits being reached and an alternative approach based upon the sensitivity of monitoring instruments. Both approaches have their merits and are still valid under IRR99.

NRPB DL2 Approach

NRPB DL2 formed the basis of the derived levels of surface contamination that were used in the Medical and Dental Guidance Notes which accompanied IRR85. Three main types of area were considered in DL2 and these were :-

active areas - areas where only classified personnel have access, ie controlled areas

inactive areas - areas where non-classified personnel and members of the public have access, ie supervised and non-designated areas

skin

DL2 used a very cautious approach with its models. In active areas it was considered that external irradiation of the skin and inhalation of resuspended activity would be the most limiting factors. In assessing the external radiation hazard it was assumed that the skin was in contact with contaminated surfaces throughout all working hours, ie 2000 hours per annum. Therefore it was the activity that gave a dose-rate of 0.25 mSv h^{-1} (equivalent to 500 mSv annual limit for the skin) that was the limiting factor. *(the 500 mSv limit for the skin is still in place but the area that this can be averaged over has been reduced from 100 cm^2 to 1 cm^2)* For the inhalation of resuspended activity it was assumed that there was widespread contamination of 10 m^2 and a resuspension factor of $5x10^{-5}$ m^{-1} was used based on dusts. The limiting factor for active areas was found to external irradiation of the skin in all cases except for H-3, Ni-63, Sr-90, Cd-109, I-125 and alpha emitters. *(For inhalation whole body dose limit reduced from 50 mSv to 20 mSv per annum with IRR99 but dose coefficients have also been revised so a simple proportional reduction is not possible and each radionuclide has to be looked at individually)*

The most important exposure pathways for contamination of the skin were considered to be external irradiation and ingestion of material from the skin. It was assumed that any contamination on the skin remained there throughout the year - equivalent to a dose-rate of 57 microsievert h^{-1} for an annual limit of 500 mSv. For ingestion, it was considered that the contaminated person ingested activity from 10 cm^2 per day.

In inactive areas it was considered that workers may not be wearing protective clothing or observing special hygiene standards and that members of the public might occasionally be present. It was cautiously assumed therefore that 10 cm^2 of contamination may be ingested each day. This exposure model therefore produced the same DLs as for skin contamination.

It was decided that because the differences between the DLs for surface contamination and skin contamination were small it was satisfactory to assign the lower value of DL for both surfaces. It was also suggested that adequate protection in inactive areas is provided by applying the most restrictive values for the surfaces of active areas and of skin. However, when later considering the monitoring for skin contamination they decided that it was appropriate to reduce the DL by a factor of 10 because hand monitors average over 300 cm^2 but contamination is usually in discrete areas, eg finger tips. They state, however, that no such reduction is required when skin is monitored by a small area probe. The radionuclides were then grouped together in a toxicity classification and the DL for the most restrictive radionuclide in each group used. These numbers were further rounded down to give the simple classification of DLs based on $3x10^x$ Bq cm^{-2} (with ‘x’ increasing as the toxicity decreases).

For all those radionuclides where the limiting factor was external irradiation of the skin the small changes to the ALIs and the reduction in the whole body dose limits has still left the external radiation of the skin as the limiting factor. For those other isotopes where inhalation or ingestion was the limiting factor the reworking of the dose coefficients/ALIs in ICRP 68 has actually led to some slight increases. In the case of H-3, in DL2 NRPB used an approximate ALI of 10^8 Bq for organically bound tritium instead of using the higher value for tritiated water. ICRP 68 now gives a dose coefficient for OBT which corresponds to an ALI (20 mSv) of $4.8x10^8$ Bq. In the case of I-125 the limiting ALI for ingestion has increased slightly from $4x10^2$ Bq to $5.2x10^2$ Bq. People working with uranium and thorium compounds will find that there has been slight increases in the most restrictive ALIs.

Therefore one could still use DL2 as a basis for surface contamination action levels. If you used the NRPB DL2 model, put a limit on the extent of contamination at 1 m^2 and

note that the figures for skin contamination can only be averaged over 1 cm^2 then you will arrive at the simple table below -

Surface	**Level of contamination that should not be exceeded (Bq cm^{-2})**				
	Class I	Class II	Class III	Class IV	Class V
Active areas	3	30	30	300	3000
Other Areas and skin	3	3	30*	300	3000

*For skin contamination by alpha emitters in Class III reduce by a factor of 10.

Examples of toxicity classification:

Class I Th-nat, U-234

Class II U-nat, U-dep, U-238, Pb-210

Class III P-32, Rb-86, P-33, Ca-45, Na-22

Class IV C-14, S-35, Tc-99m, Cd-109, I-125

Class V H-3, Cr-51, Fe-55, Ni-63

For some radionuclides the above contamination action levels are very high, especially with averaging over large areas permitted for surfaces other than skin and the levels could not be described as ‘as low as reasonably achievable’. It is better to consider them in the context of dose limits and contamination should really be kept as low as reasonably practicable below these levels.

Alternative approach based on monitor sensitivity

One University in setting action levels for surface contamination (*See Ref E10*) looked at the data in NRPB DL2 but considered each radionuclide individually and looked at the sensitivity of available monitoring instruments.

In setting action levels they considered it was important not to set levels that were too low, that posed little hazard and were hard to differentiate from background levels. If routine monitoring is made too difficult there is the risk of people not bothering to do it and if operational controls are not being followed there could be penalties from the regulating authorities.

If one considers the monitoring capabilities of available instruments, in general the more hazardous radionuclides have more energetic emissions and greater monitor responses. One can therefore choose action levels based on monitor response and one action level can be chosen for each type of instrument for the radionuclides that it can detect. This simple system makes life easy for the user and is based on the principle of what is reasonably practicable. The following action levels were set for Mini Instruments monitors (cps above background) :-

Mini E 40cps (for all betas excl H-3)

Mini EL/EP15 100cps (for all betas excl H-3)

Mini 5.44A	100cps	(for I-125 and electron capture isotopes)
Mini 5.44B	100cps	(as for 44A plus Cr-51)

Some may still consider these levels high but they are given with the caveat that ‘all contamination should be kept as low as reasonably achievable and less than the action level’. Users can not then claim that they are being asked to do something unreasonable and they have no defence if contamination is found above the action level. For comparison these action levels are compared with DL2 in the table below.

Radionuclide	**40cps on Mini E**	**100 cps on Mini EL**	**100 cps on Mini 44A/B**	**DL2**
	(equivalent Bq cm^{-2} for the above action levels)			
C-14	60	71	-	300
S-35	60	71	-	300
P-32	21	19	-	30
I-125	-	-	27	300
Cr-51	-	-	360 (B probe only)	3000

Action levels can be marked on monitors together with the radionuclides that the monitor is suitable for. The action levels can also be adjusted according to the sensitivity of individual instruments if this is felt appropriate.

Appendix 11 - RECORD KEEPING

The following records have to be kept under either IRR99, RSA93, 1996 Transport Regulations or associated ACOPs and guidance documents. Each organisation must decide whether to keep these records centrally or on a departmental basis.

Record	**Time to be retained**	**Reference**
Classified worker records	min 50 years (by ADS)	IRR99 Reg 21.3a
Summary of dose records from ADS	at least 2 years from end of calendar year to which summary relates	IRR99 Reg 21.7
Report of investigation relating to estimated dose	2 years	IRR99 Reg 22.4
Accident dose assessment	min 50 years	IRR99 Reg 23.2b
Health record of classified person	min 50 years	IRR99 Reg 24.3
Investigation into overexposure	min 50 years	IRR99 Reg 25.2b

Investigation report for doses over the investigation level	at least 2 years recommended	IRR99 Reg 8.7 (acop para 162)
Leak tests of sealed sources	until next record made or at least 2 years from date of disposal	IRR99 Reg 27.3
Accounting for radioactive substances - general	until 4 years after date of disposal or removal (5 years in Scotland)	RSA 93 (ITN/RSA/10)
Disposal of long-lived radionuclides to drains (except H-3 and C-14)	Indefinitely	RSA 93 (ITN/RSA/10)
Disposal of low-level waste to landfill for 'burial at a specified location'	Indefinitely	RSA 93 (ITN/RSA/10)
Use of radioactive material in environmental tracer tests	Indefinitely	RSA 93 (ITN/RSA/10)
Records of incidents of spillages or inadvertent release of material or loss or theft	Indefinitely (50 years)	RSA 93 (ITN/RSA/10) (IRR 99 Reg 30.5)
Testing of respiratory protective equipment	at least 2 years	IRR 99 Reg 10.2
Monitoring of designated areas	at least 2 years	IRR 99 Reg 18.5, IRR 99 Reg 19.4
Testing of monitoring equipment	at least 2 years	IRR 99 Reg 19.4
Transport documents	2 years from date of shipment	SI 1996 No.1350 Reg 26.1 and Reg 28.3

Appendix 12 - GLOSSARY OF TERMS

Annual Limit on Intake (ALI)

for any radionuclide the ALI (Bq) is obtained by dividing the annual average effective dose limit (0.02 Sv) by the dose coefficient e(50). *(see ICRP 68)*

Classified Worker - someone who is likely to receive an annual dose in excess of 6 mSv and is so designated in accordance with Reg 20 of IRR99.

Dose

Absorbed Dose - quantity of energy imparted by ionising radiation to a unit mass of matter. Measured in gray (Gy) , joules per kilogram (J kg^{-1}).

Equivalent Dose - quantity obtained by multiplying the absorbed dose by a factor that takes into account the effectiveness of different types of ionising radiations in causing harm to tissue in man. Measured in sievert (Sv), joules per kilogram (J kg^{-1}).

Effective Dose - quantity obtained by multiplying the equivalent dose to various tissues by the appropriate tissue weighting factor and summing the products. Measured in sievert (Sv), joules per kilogram (J kg^{-1}).

Dose coefficient- e(50) is the committed effective dose per unit of intake over 50 years. Measured in sievert per becquerel (Sv Bq^{-1}).

Dose Constraint - a restriction on the prospective doses to individuals which may result from a defined source, for use at the planning stage in radiation protection whenever optimisation is involved.

Practice - human activity that can increase the exposure of individuals to radiation from an artificial source.

Radioactive Substance

Under IRR 99 - a substance containing significant quantities of one or more radionuclide. Significant meaning where the quantity and activity concentration exceeds the values given in schedule 8 columns 2 and 3.

Under RSA 93 - where the activity concentration is greater than 0.4 Bq per gram. See substances of low activity exemption order for further details.

Sealed source a radioactive substance in a container designed to prevent the release of radioactive material into the environment under normal conditions of usage.

Appendix 13 - REFERENCES

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ISBN 0-7176-1746-7

A4. HSE Information Sheet

Ionising Radiation Protection Series No.5 (IRP 5)

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Specification. Sealed radioactive sources

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B2. BS 7258:1994

Laboratory Fume Cupboards

ISBN 0580227030

B3. BS DD 66: 1980

Methods of leak testing for sealed radioactive sources

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ISBN 0 08 041144 4

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D2. No.5: Notes for Training Radiation Workers in Universities (1994)

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