Local Rules for work with radioactive materials

1. INTRODUCTION

The local rules apply to work with the open/unsealed radioactive sources, liquid scintillation standards and closed radiation sources. They are the general principles and a description of the means of complying with the Environmental Permitting Regulations 2010 and the radiation protection duties imposed upon the University by the IRR17 "Ionising Radiations Regulations 2017".
The rules also include procedures to ensure compliance with the conditions of the Department's Permits under the Environment Agency's permit *ref EPR/FB3898DS*.
The University Safety Office policy statement S1/12 (Rev 2017/12) "Management of work with ionising radiation at the University of Oxford" also applies.
The local rules apply to work specifically with respect to the radiation risks associated with work with electron microscopes and the associated use of uranium radioactive compounds. The University Safety Office published a guidance RSID 9 (Rev 2016/10)**:** "Electron microscopy & associated use of uranium compounds".

COMPLIANCE WITH THESE LOCAL RULES BY ALL PERSONS IS MANDATORY

2. CONTACTS

Senior Radiation Protection Supervisor (SRPS):

Dr Zuzana Bencokova Tel: 87787 Email: zuzana@well.ox.ac.uk

Health and Safety Manager:

Dr Mike Challen Tel: 87874 Email: mike.challen@well.ox.ac.uk

A list of WHG **Radiation Protection Supervisor (RPSs)** is included in **appendix 1**.

The RPSs are responsible for supervising the work with radioactive materials to ensure compliance with these Local Rules, the conditions of the EPA permits and relevant EPR exemption conditions (specifically relating to work with uranium and thorium compounds). Also ensuring that the radiation users in their groups are trained appropriately.

University Radiation Protection Officer (URPO):

Mark Bradley (URPO) Tel: 70802 Email: mark.bradley@safety.ox.ac.uk

The UPRO may be contacted for advice on all radiation protection matters.

3. DESIGNATION OF AREAS

Work with unsealed radioactive sources is typically carried out within radiation suites designated as SUPERVISED AREAS[1]. These rooms are indicated by appropriate signs at the entrance.

Any CONTROLLED AREAS[2] if present within a supervised area (including those temporarily designated during higher risk work) will be indicated with a further "controlled area" sign. The extent of the controlled area will be defined and delineated using appropriate signs. Local access restriction arrangements will be in place.

Work with electron microscopes does not warrant any specific access control measures, but the associated use of uranium salts in powder form and solution require temporary designation of a supervised area. Such areas are required where work is usually of low risk but it is considered necessary to keep the working conditions under review on radiation safety grounds.

4. INVESTIGATION LEVELS

The University has set a dose investigation level of 1 mSv per year body dose. This Department and the Safety Office will undertake an investigation if anyone receives a cumulative dose of radiation in excess of this figure during a year. See contingency plans in **appendix 3**.

External exposures (whole body) above this investigation level are not reasonably foreseeable during routine work using open and closed sources due to the use of shielded screens where necessary. External exposures could give rise to significant extremity exposures during poor handling techniques. To minimise these risks, these local rules specify principle of ALARP 'as low as reasonably practicable' and shielding such as use of pipette shields where practicable.

Internal exposures above the investigation level are not reasonably foreseeable since, at the very least, they would require an individual to ingest 65 kBq of material or to inhale 130 kBq. No current experiments carry a significant inhalation risk.

Anyone following good laboratory practices during work with electron microscopes or uranium compounds for EM staining could not reasonably approach this investigation level of 1mSv body dose.

Nonetheless, the SRPS and URPO should be informed of any significant exposure incident or personal contamination with any isotope.

5. AUTHORISED USE

5.1 Only registered radiation workers who have attended a Safety Office radiation protection lecture and have received specific training in departmental procedures by the WHG RPS or SRPS are permitted to work with ionising radiation. The training records (**appendix 6**) are updated and kept by SRPS.

5.2 Active users are those who have been using the radiation in the last 3 years. Only active users will be registered. All non-active users will be deregistered. If they wish to restart radiation work, they need to be registered / trained again.

5.3 No order may be placed for radioactive materials without the authorisation of the Senior Radiation Protection Supervisor or their approved deputy (such as an authorised RPS).

5.4 The SRPS must be informed of all proposed new work with ionising radiation or changes of methods/techniques. The SRPS will notify the URPO in advance of commencing any new work.

[1] Supervised areas are those where radioactive materials are held which may not generate significant risks of exposure or contamination spread, but would nonetheless benefit from being kept under review.

[2] Controlled areas are areas where radiation safety procedures must be followed because of the potential for access to high radiation levels or the spread of radioactive contamination outside the area.

5.5 No work with open sources must be carried out unless a risk assessment, radioactive waste stream analysis and COSHH assessment have been carried out. Use the University risk assessment form as outlined in **appendix 4**.

5.6 The Risk assessment for use of electron microscope and written arrangements for work with uranium salts in electron microscopy are outlined in **appendix 10** and **appendix 11**.

5.7 List of approved active protocols are displayed on our intranet page http://www.well.ox.ac.uk/users-radiation-protocols-appendix-5-compliant

5.8 Work with radiation must not be performed alone or outside of normal working hours unless appropriate authorisation has been obtained from the SRPS, based on the outcome of a risk assessment.

5.9 Except where such access is granted for collaborative work and has been authorised by the SRPS, any access to open source laboratories by visitors (e.g. service engineers, cleaners) must only be granted once all radioactive sources have been returned to storage and the room monitored and declared clear of radioactive contamination. Visitors must be authorised by the RPS and supervised by a laboratory worker. Contractor's risk assessment and induction must be completed prior maintenance or cleaning works in supervised and controlled areas.

6. PERSONAL PROTECTION

6.1 All persons should take care to ensure that their own and others' exposures to ionising radiation are 'as low as reasonably practicable' (ALARP).

6.2 "Time, distance and shielding" should be employed to restrict radiation exposures during work. In particular, radioactive sources must not be handled directly. Handling tools should be used and whenever practicable, radioactive sources should be handled behind appropriate shielding.

6.3 Follow all **WHG Laboratory Rules** (**appendix 9**) when in the radioactive laboratory.

6.4 All persons issued with a radiation dosimeter (body or extremity) must wear it in the appropriate position at all times whilst at work with ionising radiation.

6.5 If you consider that you might have received a radiation exposure or intake *greater than expected* notify the SRPS, informing them of the circumstances of the potential exposure e.g. isotope, equipment, proximity, duration of exposure etc.

6.6 It is important that female workers notify the SRPS or their RPS as soon as possible if they are pregnant or breastfeeding. The working practices of the individual may need to be altered depending on the risk of exposure to the foetus/infant.

6.7 The exchange of dosimeter cards is arranged by the SRPS or by nominated RPS. The positive dose results are sent to card holders.

7. ROUTINE SOURCE ACCOUNTANCY, DOSE RATE & CONTAMINATION MONITORING

7.1 An inventory should be kept of all radioactive materials including uranium compounds on the premises. A monthly check should be made of the continued presence of all radioactive materials by physically checking the store holdings against the inventory. Records should be kept. If the whereabouts of a radioactive source cannot be confirmed immediately, notify the SRPS and URPO in accordance with the contingency plans.

7.2 Laboratory record sheets should be completed after each isotope including uranium compounds dispensing operation and following all disposals of radioactive waste. These sheets are available within the laboratory. Separate procedures for stock and subsequent containers records detailed in the **appendix 11** apply for the work with uranium compounds.

7.3 Areas where work with open sources is carried out must be monitored for radioactive contamination weekly when in use. Results should be recorded in the routine contamination monitoring sheet. Any radioactive contamination must be dealt with.

7.4 Each individual worker must ensure that work areas and equipment are free of contamination before and after each use using a suitable and functional contamination monitor. Contamination and dose rate monitoring should be performed (as appropriate) throughout the work. For work with ^{3}H where hand held instruments have no response, checks for contamination should be performed using wipes and liquid scintillation counting. Results should be recorded.

8. ORDERS & DELIVERIES OF RADIOISOTOPES

8.1 All orders for radioactive materials must be placed or authorised by trained RPS. The RPS authorising the order must confirm that proposed orders would not lead to a breach of the limits for the laboratory. The SRPS will give the final authorisation of the order to the Accounts Team before they place the order. See **appendix 2 SOP1**.

8.2 Isotope deliveries during office hours must be made to Goods-In. On arrival, Goods-In staff will confirm that the package is addressed to the Department and will immediately contact the Senior Radiation Protection Supervisor to collect the package or arrange collection by the RPS. Until the package is collected, it will be locked in a secure store inside Goods-In.

8.3 The SRPS/RPS collecting the delivery from Goods-In must follow the procedure in **appendix 2 SOP2**.

8.4 At the radiation suite, the SRPS or RPS delivering the new stock pots of radioactive materials will check for contamination (outside package, outside internal container/lead pot, outside vial) Checks should be made using a suitable contamination monitor.

8.5 On delivery of the package to the radiation suite, the RPS or the radiation user will be instructed to secure the material in a locked radiation store.

9. KEEPING & USE OF RADIOACTIVE MATERIALS

Storage

9.1 When not in use, keep radionuclide stocks and solutions in a locked fire-resistant cupboard or locked, labelled fridge/freezer. The stock pots and solutions should be stored within secondary containment to minimise the risk of contaminating the store/fridge.

9.2 No materials, other than those related to the work with radiation (e.g. handling tools, hand held radiation monitors) should be kept in the store. Where fridge/freezers are necessarily used to store both radioactive and non-radioactive materials, the radioactive materials must be kept within a separate locked compartment or locked box within the appliance.

9.3 All radioactive solutions and materials should be clearly labelled to indicate the source pot number, radionuclide, radioactivity, date and owner.

Work with open sources

9.4 Ensure that you have all equipment necessary for the experiment to hand before commencing work, including a suitable contamination monitor.

9.5 Work with liquids over lipped trays. Work with volatile materials, gases, vapour or aerosols in a fume cupboard. Use handling tools where identified in the risk assessments.

9.6 Work with high energy beta or gamma emitters should be carried out behind appropriate shielding (lead acrylic for gamma emitters and bremsstrahlung; polycarbonate for beta emitters) e.g. splash shields, pipette shields, shielded racks and bins.

9.7 Monitor hands and work-areas frequently and after concluding each specific work stage. Always assume

that gloves are contaminated during and after handling radioactive materials. Prior to handling items e.g. pens, notebooks, telephones, door handles etc. check for contamination using the contamination monitor or wipes scintillation counter detection when working with the ^{3}H

9.8 If contamination is detected, make safe and investigate. Follow the procedures for a spill detailed in the contingency plans. If laboratory coats, personal clothing or skin becomes contaminated, the RPS must be informed immediately. See contingency plans in **appendix 3**.

9.9 Decontaminate and monitor all items before removing them from the laboratory. The de-contamination certificate must be completed and then authorised by the SRPS.

9.10 Before leaving the laboratory, monitor work surfaces and equipment used (record on log sheets), lab coat and gloves. Remove and dispose of gloves. If contamination is found, follow procedures for a minor spill detailed in the contingency plans in **appendix 3**.

10. DISPOSAL OF RADIOACTIVE WASTE

10.1 Before commencing an experiment consult the relevant disposal record sheets to ensure any waste which would be generated would not result in the monthly waste limits for the laboratory being exceeded.

10.2 **Aqueous waste** can only be disposed of down a designated sink. Aqueous waste should not be held on the bench and must be disposed as soon as possible after generation. It should be flushed through with large volumes of water. The monthly aqueous waste disposal limit for each isotope posted by the sink and must not be exceeded. Following each disposal, a signed/dated entry should be made on the Monthly Record of Radioactive Waste Put to Drains (green) sheet of the isotope. Activity disposed of and also the stock pot reference number should be entered. An entry for cross reference should also be made on the Radionuclide Record Sheet.

10.3 Specifically for liquid **uranium and thorium waste**, a maximum of 5 g in mass[3] may be disposed of per week down a laboratory sink. It should be flushed down with large quantities of water. A record should be kept of the mass (in grams) of radioactive waste disposed of down the drain each day.

10.4 **Solid and organic liquid waste:** Appropriate containers must be used for experimental waste on generation e.g. beta-boxes. On completion of work, radioactive waste generated should be transferred to the appropriate radioactive waste bin.

10.5 All waste items placed in bins must be recorded on the bin record sheet at the time of disposal. Bin activity limits stated on the bin record sheets must not be exceeded. There are other important restrictions on the quantity and type of waste which may be placed in the bins. These restrictions are quoted on the bin record sheet and must be followed. Also see **appendix 8.**

10.6 The combined mass[3] of **uranium and thorium** in the department's accumulating radioactive waste must not exceed 100g at any time. Arrangements for collection by the Safety Office of radioactive waste for disposal should be made by contacting Simon Haycox at radwaste@safety.ox.ac.uk. The total mass of uranium (and thorium) atoms removed from the premises for disposal as solid waste must not exceed 500g in any one week. A record should be kept of the mass (in grams) of disposals of solid radioactive waste.

10.7 WHG obtained written authorisation from the URPO to dispose **small quantities of solid uranium waste** produced during the EM staining procedures to the general non-hazardous waste stream. See **appendix 2 SOP3 Note 6.** The limits of 0.1 % must not be exceeded.

10.8 Accumulating waste which is not under the continuous supervision of a registered radiation worker must be secured against access by non-registered workers. At the very least, waste should be transferred to the radiation bins in the designated radiation suites at the end of each procedure.

[3] Where mass is mass of uranium atoms, not mass of compound.

10.9 Waste must not be accumulated beyond the authorised accumulation period.

10.10 **Gaseous discharges** can only be released from designated fume hoods by authorised persons. The gaseous waste disposal limit for each isotope is posted by/in the hood and must not be exceeded. Following each disposal, a signed/dated entry should be made on the gaseous record sheet of the isotope and activity disposed of. Currently no protocols

10.11 Monthly returns should be sent to the Safety Office of all radioactive waste disposals/discharges from the Department. This is arranged by the SRPS at the beginning of each calendar month.

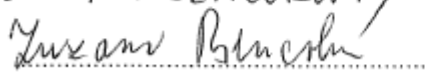
Signatures to adopt the local rules into department:

E. YVONNE JONES

..... Date: 5 Feb 2018

Centre Director

ZUZANA BENCOKOVA



..... Date: 2/2/2018

Senior RPS

LIST OF APPENDICES:

APPENDIX 1: RADIATION PROTECTION SUPERVISORS OF AREAS

RADIATION ROOM LOCATION	GROUP	RADIATION PROTECTION SUPERVISOR
HWBGM Lab 1 00/076	Knight	Julian Knight Tel: 87651/87531
HWBGM Lab 1 00/076	Lewis and Leedham	Annabel Lewis Tel: 87720
HWBGM Lab 2 EM Prep room and OPIC EM	STRUBI	Geoff Sutton Tel: 87548
HWBGM Lab 3 10/088	CVMed	James Brown Tel: 87585
HWBGM Lab 3 10/088	Transgenics	Ben Davies Tel: 87836
HWBGM Lab 4 10/143A Faxitron X-ray generator	Chapman	Ross Chapman Tel 87839/87622
HWBMP 20.15	O'Callaghan	Chris O'Callaghan Tel: 87789

APPENDIX 2:

STANDARD OPERATING PROCEDURE 1

Ordering Radioactivity

Note: Ordering Radioactivity includes making arrangements to bring radioactive materials onto the premises from another department, premises or institution.

RPS Duties For orders of material for a new protocol:

Check with the users that the use of radioactive material is justified.

Check with the users that the requested amount of isotope is the minimal amount needed (or minimum quantity that can be ordered).

Check that the users have an approved risk assessment and waste stream estimate in place.

Check the isotope is listed in the Schedule to the Certificate of Registration

Check we remain within the limits for the isotope on the WHG portion of the ORC's current permit.

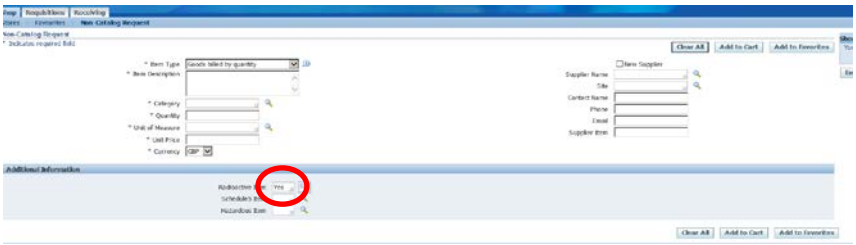
RPS Duties For all other orders and new protocol material:

Check if the sum of the existing stock activity and the ordered activity stays within the radiation limits given to the specific work location within the Centre.

Check that the waste generated by the protocol can be accommodated within the accumulation and disposal limits given to the specific work location within the Centre.

For closed sources, obtain written authorisation from the University Radiation Protection Officer that the closed source can be ordered.

When raising an R12 order with the Accounts Team, you must write "yes" in the Radiation Square. Note; if it is a catalogue item this is automatic.



Authorisation must be given by the SRPS (or their deputy) to the Accounts Team before the order can be sent to the supplier.

SRPS Duties for radioactive material orders:

Check with the RPS that the use of radioactive material is justified.

Check with the RPS that the requested amount of isotope is the minimal amount needed (or minimum quantity that can be ordered).

Check with the RPS that there is an approved risk assessment and waste stream estimate in place.

Check the isotope is listed in the Schedule to the Certificate of Registration.

Check the amount that is currently in the Centre by access the spreadsheet named “Returns Stock on Hand” located on: N:\labman\Radiation.

Check if the sum of the remaining activity and the ordered activity stays within the WHG’s portion of the limit stated on the ORC’s current Permit, also within the limits given to specific locations within the Centre.

Check that the waste generated by the protocol can be accommodated within the accumulation and disposal limits of the WHG’s portion of the limit stated on the ORC’s current Permit and the limits given to specific locations within the Centre.

For closed sources, obtain written authorisation from the University Radiation Protection Officer that the closed source can be ordered.

After all checks are complete, the SRPS or his nominee, can then authorise the ordering of the radioactive material with the Accounts Team. This is done as a reply to the R12 generated FYI email which is generated for all “radioactive” orders.

The SRPS send an email to radiationdeliveries@well.ox.ac.uk and stores@well.ox.ac.uk to notify them about the radiation order specifying:

- type of isotope
- manufacturer and catalogue number
- quantity (MBq and uL)
- who was it ordered for

The SRPS or their nominee then makes a partial entry into the Radiations delivery book to be completed on receipt of the isotope. This is to provide an awareness of commitment so that future orders won’t be placed which would take us over our permit limits.

STANDARD OPERATING PROCEDURE 2

Receiving and Opening Radioactive Packages

Delivery of Nuclide

Radiation deliveries can only be received at Goods-In during normal working hours. The Centre's Facilities Team are authorised to undertake the initial receipt of orders. The Facilities team members working in Goods-In are trained to accept radiation deliveries.

Receiving the Package from the Courier

The delivery note must be checked to ensure the package is for the correct department. If the delivery note is not correct, the package must not be accepted.

The package paperwork must be checked for the correct isotope and correct quantity of radioactive material by comparing it with the original purchase order form from the Accounts Department. Packages which are deemed to contain a different radioactive isotope or different quantity of radioactive material than what was on the original purchase order must not be accepted by the Facilities team member. If they are unsure, they can request advice from the SRPS.

All radiation deliveries will be placed directly into the yellow HazCabinet inside Goods-in. Access to the keys for this bin is limited to the named persons below only.

SRPS and designated nominees:

- Zuzana Bencokova (SRPS)
- James Brown (RPS)
- Annabelle Lewis (RPS)
- Mike Challen (H&S Manager)

Receipt of Nuclide

Stores will email radiationdeliveries@well.ox.ac.uk that a delivery of radiation has been made or inform the Helpdesk Tel: 87504 if no one responsds in an hour.

The SRPS will carry out the actual receipt or arrange for one of the above trained nominees to process delivery.

Process of Receipt

1. Person processing delivery confirms reception of delivery notification email to radiationdeliveries@well.ox.ac.uk and stores@well.ox.ac.uk.
2. Collect the 'Radiation Deliveries' book from the SRPS's Office 00.04. It should contain blank 'Radiation Material Usage Sheets'.
3. Collect the delivered Radioisotope and purchase order from the 'Yellow hazCabinet' in Stores.
4. Check paperwork is in order (correct isotope received).
5. Carry out the next steps within a Radiation Suite whilst wearing a lab coat, gloves and safety glasses.

6. Before continuing check all work areas for contamination, using a radiation contamination monitor appropriate for isotope.
7. Check the outside of the delivery for any obvious signs of contamination, again using an appropriate radiation monitor. For deliveries of Tritium, look for clear signs of damage or leakage.
8. Open the box and remove the Packing Note. (keep, to file with a photocopy of the order)
9. Check that all the purchase order, packing note and label on container details are all correct.
10. At this point assign a Unique Reference No (URN) to the isotope. This could be the batch number of the stock delivered suffixed by a unique number, according to the number of deliveries already received from that batch.
11. Remove the stock pot and check the packaging for radiation contamination.
12. Open the container and check contents are as described and present.
13. Return the stock pot to the packaging box and inform, face to face or by phone, the user or RPS to securely stow their delivery and file their Radiation Material Usage Sheet.
14. Record all the details in the 'Radiation Deliveries' Book.
15. Fill out the top of a Radiation Material Usage Sheet and leave with the package
16. Photocopy the purchase order form, add to it the packing slip and file.
17. Sign and give original purchase order and packing note to accounts department
18. Return the 'Radiation Deliveries' Book to the SRPS's Office 00.04.

STANDARD OPERATING PROCEDURE 3

Accumulation & disposal of radioactive waste

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Notes:

NOTES

1. Notes on the general application of this SOP

This SOP applies to the accumulation and disposal of radioactive waste generated by work with radioactivity carried.

Under no circumstances must radioactive waste be accumulated or disposed of in a manner contrary to the conditions of our Environment Agency's permit. Routine accumulation and disposal of radioactive waste in accordance with the conditions of the Permit is covered in **appendix 8** of these WHG local rules.

Work with ionising radiation carried out in the WHG generates the following categories of waste:

- solid radioactive waste
- aqueous radioactive waste
- organic liquid radioactive waste

No protocols are currently undertaken which could result in atmospheric releases although procedures for this category of waste is addressed in the local rules **appendix 7**. Such work would require the prior authorisation of the SRPS and the URPO and a review of this SOP.

In general for solid and organic liquid radioactive waste, waste is placed in a bin as soon as possible after generation and accumulated in strict accordance with the volume, activity and time limits specified in the Permit. Waste is not accumulated specifically to decay, although decay is a consequence of the accumulation period. Prior to collection of radioactive waste from the department, the activity of the waste is accurately calculated by decay correction.

2. General conditions for the accumulation and disposal of radioactive waste

Aqueous radioactive waste may not be accumulated and should be discharged via the designated radioactive waste disposal sinks as soon as possible after generation.

Solid and organic liquid radioactive waste must be stored in metal bins (for details see appendix 8) in the Radiation Waste store or designated radiation suites. The dose rate on the outer surface of any waste store/bin must not exceed 5 µSv per hour.

All solid radioactive waste must be disposed of by collection by the University Safety Office, within 12 months of the bin being opened (contact radwaste@safety.ox.ac.uk to arrange collection). The Safety Office will prompt the SRPS to arrange disposal of solid radioactive waste if a bin has been issued to the department for a length of time approaching 11 months.

Stores/bins used for the accumulation of radioactive waste must, so far as reasonably practicable, be secure (i.e. locked); fire resistant; shielded to achieve surfaced dose rates below 5 µSv per hour; and used only for the storage of the radioactive waste and other associated equipment. Under no circumstances must flammable, explosive, corrosive or oxidizing materials be stored with radioactive materials.

Accumulating radioactive waste which is not under the supervision of a radiation worker should be kept secure where practicable. Accumulating waste should be clearly segregated from stored radioactive material.

Clear records should be kept of the waste generated by the experiment, its accumulation and ultimate disposal.

A record must be kept using the bin record sheets provided of all accumulating waste. Records should include the date it was generated; the isotope; the activity; the researcher; and a means of referencing it exactly to its originating experiment.

All items used in a radiation room must be monitored using an approved method prior to disposal. Waste from radiation rooms is only deemed non-radioactive when monitoring confirms no count rate above background. In areas of high ambient background, monitoring should be performed by wipe which should be presented to the contamination monitor in a low background area.

3. Specific procedures for the disposal of aqueous radioactive waste

All liquid waste must be disposed of as soon as possible after generation.

Dispose of liquid waste from counting tubes in the radioactive waste sink. Flush with copious amounts of tap water. Make an entry on the liquid waste form. An entry for cross-reference must also be made on the white stock record form.

Dispose of liquid waste in a temporary flask first when generating many small aliquots. Then empty waste bottle into the radioactive waste sink. Flush with copious amounts of tap water. Make an entry on the liquid waste form. An entry for cross-reference must also be made on the white stock vial.

Emptied bottles and counting tubes should then be disposed of as solid waste as above.

4. Specific procedures for the accumulation & disposal of solid radioactive waste

All solid waste generated at the bench must be transferred to the appropriate solid waste bin as soon as possible. Waste must not be left in bench containers after completion of the experiment.

Solid waste must be placed into the coloured steel waste bins and an entry made on the waste form for the bin: fill out name, isotope, amount and date. An entry for cross-reference is also made on the white stock record form. (see appendix 8 for details)

Dose rate should be checked and must not exceed 5µSv/h at the surface of the bin to comply with legislative requirements for the transport of excepted packages.

5. Specific procedures for the accumulation & disposal of organic liquid radioactive waste

All organic liquid waste generated at the bench must be transferred to the appropriate solid waste bin as soon as possible. Waste must not be left in bench containers or in scintillation counters after completion of the experiment and results gathered.

Solid waste must be placed into the coloured steel waste bins and an entry made on the waste form for the bin: fill out name, isotope, amount and date. An entry for cross-reference is also made on the white stock record form. (see appendix 8 for details)

Dose rate should be checked and must not exceed 5µSv/h at the surface of the bin to comply with legislative requirements for the transport of excepted packages.

6. Specific procedures for the accumulation & disposal of small quantities of uranium waste

Small quantities of solid uranium waste[1] can be disposed through the general non-hazardous laboratory waste route. See **appendix 11**.

[1] Small quantities of solid uranium waste are defined when the mass of uranium constitutes less than 0.1% of the waste as a whole.

APPENDIX 3: CONTINGENCY PLANS

These contingency plans should be read and understood by all WHG active radiation users in conjunction with the University contingency plan in University Policy Statement (Ref S1/12 rev. 2017/12). All active radiation users are routinely reminded the contingency plans by the SRPS and these are rehearsed at appropriate intervals.

Introduction

The likelihood of incidents which would result in a significant risk to members of staff, emergency services personnel or members of the public is very low. However, in the event of an incident, the actions detailed in these contingency plans should be followed to ensure that radiation exposures are as low as reasonably practicable.

Nothing in this plan precludes action which needs to be taken to save life or assist an injured person. However, where such action is required in the presence of high radiation dose rates or radioactive contamination, this should be done under radiation protection supervision where possible.

When implementing any contingency plan, a record of names of all persons involved, their locations with respect to radiation sources in the laboratory and times of exposure should be kept to enable an assessment of doses to be made.

When any contingency plans are triggered, the SRPS telephone and email the UPRO. Incident is notified to the Safety Office using standard University accident report form.

Specific contingency plans are provided for the following reasonably foreseeable incidents:

1. Loss or theft of radioactive materials
2. Personal exposures
3. Spills of radioactive solutions
4. Personal Contamination
5. Skin or puncture wounds
6. Fire in the building
7. Breakdown of controls
8. Equipment faults/failures

Note: In the event of an emergency, actions assigned to the SRPS in these plans may need to be undertaken by the RPS. Also, actions assigned to the URPO in these plans may need to be undertaken by a person deputising for him. If the URPO is unavailable then the Emergency Call-out List should be used to obtain the assistance of such persons.

1. Loss or theft of radioactive materials

This might be detected at a routine source check or after unauthorised entry into the facility.

- An immediate check should be made on all radioactive sources and any missing materials identified and a description prepared of the missing materials.
- Report the circumstances without delay to the SRPS and University Safety Office who will advise on notification of the statutory authorities.
- Continue to search for the missing material.

2. Personal exposures

- Anyone who considers they may have received a significant radiation exposure (e.g. due to dose rates from unshielded beta sources or ingestion or inhalation of radioactive material) should notify the SRPS as soon as possible.
- The SRPS should be informed as soon as possible after any significant contamination; personal contamination; or release of gaseous radioactive materials outside a designated fume hood.

- The exact details of the exposure (source details, distances, exposure times, part of body, witnesses etc) should be recorded.
- The URPO should be notified forthwith.

3. Spills of radioactive solutions

General procedures for dealing with radioactive spills appear in Appendix 2 of the University of Oxford Policy Statement S1/12. Minor spills may be deal with as follows.

If possible notify the RPS or shout/telephone for someone else to do so. Do not leave the laboratory to contact the RPS. Check for personal contamination and if contamination is not regarded as being significant e.g. only small spots on sleeves or the body of the lab coat, then proceed as follows:

- The contamination monitor should be used throughout.
- Examine gloves to ensure they are intact, changing gloves and monitoring hands as necessary.
- Place absorbent material around the spill to contain and absorb the spilled liquid.
- Place soiled absorbent material in designated plastic bags and arrange for disposal as radioactive solid waste.
- Monitor the affected area and decontaminate using dry or wet tissues.
- Repeat monitoring and decontamination as required until area is clean. Use alcohol or detergent if required.

Check again for personal contamination and remove contaminated clothing; placing in a plastic bag - arrange for the bag to be marked "radioactive - contains contaminated clothing".

4. Personal contamination

Dealing with this is described in Appendix 2 of *S1/12 rev. Dec 2017*.

- This type of incident must be reported to the SRPS and URPO.
- Carefully remove contaminated clothing; placing in a plastic bag - arrange for the bag to be marked "radioactive - contains contaminated clothing".
- Contact the URPO for advice on possible assessment of intakes.

5. Skin cut or puncture wounds

Minor injury

- Directly monitor the wound and arrange for a contamination check of the article causing the injury.
- Encourage bleeding and irrigate the wound with clean water.
- Cover the wound after a few minutes irrigation and seek medical advice.
- Arrange for analysis of the injuring article or a wipe taken from it. This will help determine if there has been any significant internal radiation exposure to the individual.

Serious Injury

- Immediately summon first aid assistance and treat any life-threatening condition with priority. Lives saving measures take precedence over radiological concerns.
- If possible, directly monitor the wound but in any event arrange for a wipe to be taken from the injuring article. This will later help determine if there has been any significant internal radiation exposure to the individual.
- If the person requires removal to a hospital and he/she is heavily contaminated then, provided medical considerations allow for it, attempts should be made to remove any contaminated clothing from the person. Subject to medical advice, contaminated areas of skin should be cleaned with moist swabs. Note, advice may be sought from Occupational Health if any member of staff has badly contaminated wounds (Occupational Health 01865 282676).
- Place contaminated clothing in a plastic bag and arrange for the bag to be marked "radioactive - contains

contaminated clothing";

- If the person requires removal to a hospital then a member of staff (preferably an RPS) should accompany them with a radiation monitor to advise hospital staff of the circumstances of the accident. The URPO should be notified immediately.

5. Fire in the building

On hearing the fire alarm and provided it is safe for you to do so:

- Stop work and return radioactive stocks to the local radiation store if time allows and it is safe to do so.
- Leave the building by the prescribed route.
- Go to the assembly area and report to the acting fire warden. Notify the (S)RPS via the fire warden if any radioactive sources have not been returned to the radiation store.
- When the fire brigade arrive, the SRPS should inform them about the presence of radioactive materials within the laboratory and provide advice as required.
- If the fire has affected the part of the building in which the radioactive sources or radiation generators are situated, damage to radioactive sources/containers and the possibility of radioactive contamination must not be discounted. The advice of the URPO should be sought prior to returning to the laboratory.
- In that event, a full contamination survey should be carried out. The URPO will advise on the appropriate actions to be taken on the outcome of these checks.

6. Breakdown of controls

The RPS should notify the SRPS of any breakdown in procedural controls whether or not they resulted in significant radiation exposure. For example, the use of radioactive sources or access into controlled areas by unauthorised/non-registered staff. The SRPS should investigate all notified incidents to determine whether existing procedures remain sufficient and the advice of the URPO should be sought.

7. *X-ray generator faults/failures*

In an event of any safety related equipment fault/failure (e.g. failed door interlock function of the Faxitron X-ray irradiator), close immediately the door immediately, remove the power supply, notify (S)RPS and do not re-use the equipment until the service engineer has corrected the fault.

APPENDIX 4

University of Oxford open radiation source risk assessment form

Read the notes overleaf before completing this form. If insufficient space is available use a separate piece of paper & attach it to the form. Refer also to University of Oxford Generic Open Source Risk Assessment.	File ref:	Date:

Department:	**Persons involved**	**Others at risk**
Location of work:		

Description of procedure:

.

Substance used	Quantities used (MBq)	Frequency of use	Hazards identified	Exposure route	Dose per procedure (μSv)
	Stock: *Per assay:*			whole body Y / N skin Y / N eyes Y / N inhalation Y / N ingestion Y / N absorption Y / N	*Whole body:* *Extremities:* *Eye:*

Could a less hazardous substance (or form of the substance) be used instead ? Yes / No

Justify not using it:

Could a lower activity be used? Yes / No

Justify quantity of material in use:

What measures have you taken to control risk?

Engineering controls & safety equipment:

Procedural & management controls:

PPE:

Checks on control measures:

Radiation monitor:		**Training requirements:**
Is dosimetry required?	Yes / No	
Type of dosimetry:	Whole body / Finger / Eye / Biological	

Emergency procedures: **Decontamination procedures:**	**Waste disposal**: Waste stream flowchart appended Solid (%): Aqueous (%): Organic liquid (%): Gaseous (%):

Are overall risk control measures adequate? Yes / No	**Signature:**
Name & position of assessor:	**Signature**:
Name of radiation protection supervisor:	**Signature**:

Date of routine review	Date:	/ /	/ /	/ /	/ /	/ /
	By:					

Notes on completion of University of Oxford open radiation source risk assessment form

Location of work: Include room number & designation i.e. “controlled” or “supervised” area.

Persons involved / Others at risk: Include all those performing the experiment. Consider co-workers, maintenance staff, cleaners etc.

Description of protocol: This should be recorded in sufficient detail to allow an assessment to be made of the radiation risks throughout the various stages of the experiment. Alternatively, reference may be made to a separate record but this must be readily available when reviewing the risk assessment.

Substance used: Product name including isotope.

Quantities used: The activity of the stock pot affects likely extremity exposures during initial dispensing operations & also the potential whole body exposures from the entire stock. The activity per assay allows a more realistic assessment of exposures during typical manipulations during the procedure.

Frequency of use: How many times is radioactivity handled? This will allow a projected annual exposure to be calculated.

Hazards identified: What radiations (i.e. α, β/electron, γ, x) are emitted? Are they penetrating i.e. do they present a significant external hazard to the whole body; to the skin; or solely an internal hazard? All proposed α work should be discussed in advance with the URPO.

Exposure route: What are the potential exposure routes from this experiment? External whole body; external skin; internal by ingestion, inhalation or absorption? Whilst an isotope may present a significant hazard, if exposure to that hazard is not foreseeable during the experiment, it need not be considered further e.g. if no gaseous or volatile products/aerosols are created, inhalation risks can be discounted; but this fact should be recorded.

Dose per procedure: *Delacroix* external & internal exposure data can be used to estimate doses during the experiment. Dose rates from unshielded stock pots can be estimated from the *10 ml glass vial* data & extremity exposures during pipetting can be estimated from *point source* data. Eppendorfs can similarly be considered as unshielded point sources. *Delacroix* shielding data (together with a radiation monitor) should be used to confirm the effectiveness of shielded blocks & screens. Doses from intakes can be estimated from the *20 mSv ALI* data (the activity which on intake would result in a 20 mSv effective dose). If annual whole body doses could approach the University’s 1 mSv investigation level as a result of all procedures undertaken by an individual, or extremity doses could approach 50 mSv / eye doses could exceed 1 mSv, the URPO should be informed. These are considered significant exposures.

Could a less hazardous substance be used instead? Justify not using it. This section of the form should be used to detail any alternative techniques & commentary on their suitability in comparison to radioactive techniques. For work to be authorised, this justification section must conclude that the use of radioactivity is the only practicable option to achieve the necessary outcome & that the scientific benefits of using radioactive material offset any risks associated with its use i.e. the use of radioactivity cannot be avoided. Where relevant you should consult colleagues, peer groups, other institutions & research papers & relevant publications to determine whether non-radioactive alternatives exist. For established techniques commonly in use, justification may be a simple reference to previous research papers or peer reviewed journals.

Could a lower activity be used? Justify not using it. This section should document the decision on the initial activity to use for each assay & the reason why no lower activity can be used. If, for example, a minimum starting activity is required to achieve the required endpoint (e.g. a satisfactory autoradiograph), this should be recorded. This *optimisation* will ensure that radiation exposures & any radioactive wastes arising from the procedure are minimised. Use of higher activities would serve only to increase personal exposures or generate excessive waste.

What measures have you taken to control risk? *Engineering controls & safety equipment:* In this section, you should record considerations regarding choice of equipment & facilities to restrict exposures & minimise contamination spread e.g. containment (including hoods), shielding etc. & emergency kits. *Procedural & management controls:* Further to the hardware controls, what instructions need to be written down (in the local rules) to ensure people work safely i.e. dos & don’ts. *Personal protective equipment:* Finally, list additional PPE to be worn during work.

Checks on control measures: Record any checks required to ensure effectiveness of control measures. Include specific radiation & contamination monitoring regime; fume hood maintenance etc. Radioactive stock & waste accounting.

Radiation monitor: Identify a suitable radiation monitor available in the laboratory for contamination or dose rate monitoring as appropriate. No hand held monitors are suitable for ^{3}H monitoring. End window GM detectors (e.g. 900E/EP15) reading in *cps* are generally suitable for contamination monitoring of most beta emitters. For photon emitters, a scintillation counter (e.g. 900 42A/B, 44A/B) should be used. Photon *dose rate* measurements should be considered carefully in consultation with the URPO since the energy response of commonly available instruments may not be suitable for certain isotopes.

Is dosimetry required? / Type of dosimetry: A *whole body dosemeter* should be worn when working with photon emitting isotopes, including positron emitters, unless dose rates below 2.5 μSv/h are achieved at the edge of bench by shielded screens (polycarbonate for $\beta/\beta+$ or lead acrylic for γ). For work with high energy β-emitters where protection against whole body doses is afforded by shielded screens, no whole body dosimetry is required. If shielded screens cannot be used, whole body dosemeters should be worn. Dosemeters are not necessary for work with soft β-emitters, e.g. ^{14}C, ^{33}P, ^{35}S. *Extremity dosemeters* should be worn if the work requires you to routinely pipette from 9.25 MBq stocks of high energy β- or positron emitters or manipulate single aliquots of that order. The dose rate to the hand would be of the order 10 mSv/h using an unshielded Gilson pipette and handling times of 5 hours would lead to extremity doses approaching 10% of the relevant dose limit. Assessment of extremity doses would therefore be appropriate. Use of suitable pipette shields would obviate the need for extremity dosimetry during these operations & should therefore be considered. Extremity dosimetry should only be necessary for gamma emitters if more than 50 MBq is routinely manipulated in a single aliquot. *Extremity dosemeters* should also be worn by new workers for a limited period to confirm good isotope handling techniques. *Eye dosemeters* should be worn (at least initially) if annual exposures could exceed 1 mSv.

Training requirements: Detail any theoretical, laboratory induction, & practical training required by anyone undertaking the experiment.

Emergency procedures / Decontamination procedures: Detail any specific contingency plans required to address reasonably foreseeable incidents which could occur during the experiment. Alternatively, confirm that the existing contingency plans in departmental local rules are appropriate.

Waste disposal: Having optimised the activity in the experiment, an estimate is required of the type & quantity of waste which will be generated. This is required for the purposes of assigning group limits to guarantee compliance with Certificate conditions. A waste stream assessment should be appended to this risk assessment. Where the activity of waste depends on the outcome of the experiment (i.e. the uptake) & where waste quantities are reported accurately following liquid scintillation or gamma counting to assess the success of the

procedure, an approximate or worst case figure will be required at the outset to allow realistic waste limits to be assigned to user groups. Waste streams assessments should be routinely reviewed.

Statement of adequacy of overall risk control measures: The purpose of a risk assessment is to identify whether you are doing all that is reasonably practicable to restrict radiation exposures of workers & other persons, either directly from the work activity or from the resulting radioactive waste. It should guide the preparation of safety procedures. Your risk assessment is likely to be "suitable & sufficient" if you have reached a point where you consider that any further controls you could adopt would either impede or prevent you from carrying out the work, or would involve significant engineering or expense to enable you to do so. Alternatively, if you feel more could easily be done, you should review the adequacy of the assessment before it is signed off.

Names & signatures: The name, capacity & signature of the assessor should be included together with the name & signature of the RPS responsible for the laboratory where the experiment will be undertaken.

Review: Risk assessments should be reviewed at least annually by the group (& RPS) undertaking the work. The section at the foot of this page should be dated & signed by the lead assessor on completion of the review. The significant findings of these reviews should be recorded & any necessary revisions made to protocols or safety procedures.

Appendix 4.1: Protocol

Appendix 4.2: Dose assessment

Appendix 4.3: Waste stream assessment

APPENDIX 5: WASTE PROTOCOL

Disposal Methods of Radioactive Material

Name of Radiation User:		**Name of RPS:**	
Group:		**Date of Assessment:**	

Overview of Project to be undertaken:
Radionuclide to be used (MBq):
Amount of Radionuclide to be used per Experiment:
For each stage of the experiment - Detail the amount of radionuclide (MBq) that you **estimate** to be taken up or lost to waste. Detail for each stage whether this waste is liquid or solid.

Estimated Total amount of Liquid Waste:	**Estimated Total amount of Solid Waste:**
Est. Liquid Waste as a % of the Total used:	**Est. Solid Waste as a % of the Total Used:**

Determine if the estimated waste figure calculated above is a true result. Affix any actual data gathered to this document to support the Waste Management Protocol.	
Actual Total amount of Liquid Waste:	**Actual Total amount of Solid Waste:**
Actual Liquid Waste as a % of the Total Used:	**Actual Solid Waste as a % of the Total Used:**

APPENDIX 6: Radiation worker training record

Name:

Academic supervisor / line manager:

Date of registration:

Details of work:

The following tables should be used to record the training provide to the Department's radiation workers. Only complete those sections where information, instruction and training has been provided. Where this is not applicable write "N/A".

1. Training record for all work with radioactive materials

Topic	Details	Date	Trainer signature	Worker signature
Registration	Confirmation of radiation worker registration received from Safety Office			
URPO lecture	Radiation safety for laboratory workers (open sources & irradiators)			
	Radiation safety for closed sources & radiation generators			
Familiarisation	Use of radiation within dept / group			
	Radiation working areas			
	Introduction to relevant SRPS and RPS			
Rules	Requirements of Departmental radiation safety policy & procedures			
	Requirements of Departmental local rules			
	EPR2010 Permit conditions			
	Authorised isotopes and group limits for use, accumulation, disposal			
Hazards & risks	Hazards associated with authorised isotopes / authorised equipment			
	Findings of risk assessment			
	Appropriate risk control measures incl. time, distance, shielding.			
	PPE requirements			
Monitoring	Selection of suitable radiation / contamination monitor			
	Technique / use of monitors			
	Monitoring records			
Dosimetry	Wear and care of personal dosemeters			

2. Training record for work with open sources

Topic	Details			Date	Trainer signature	Worker signature
Practical competence	Setting up workstation					
	Source handling techniques / aliquoting					
	Opening the pot					
	Operation of equipment (insert specific details)	*1.*				
		2.				
		3.				
		4.				
		5.				
Rules & procedures	Ordering procedures		Ref SOP1			
	Approval of protocols					
	Preparation & approval of risk assessments					
	Receiving & opening packages		Ref SOP2			
	Package acceptance checks incl. contamination					
	Source accountancy & security					
	Opening pot					
	Record keeping – completion of stock / dispensing record					
	Waste accumulation procedures		Ref SOP3			
	Dealing with bench generated wastes					
	Segregation of waste into bins					
	Record keeping – completion of bin record sheet					
	Waste acceptance criteria / bin conditions & limits					
	Waste security					
	Maximum accumulation period					
	Aqueous / gaseous waste disposal procedures					
	Designated discharge points					
	Activity limits for discharges to drain and atmosphere					
	Record keeping – completion of waste disposal records					
	Performance and recording of contamination monitoring					
	Decontamination procedures					
	Implementation of contingency plans incl. emergency assistance					
Limits	Stock limits					
	Waste accumulation limits					
	Waste disposal limits (aqueous, gaseous, organic liquid, solid)					
Protocols	1.	Observed protocol				
		Performed under supervision				
		Authorised to perform unsupervised				
	2.	Observed protocol				
		Performed under supervision				
		Authorised to perform unsupervised				
	3.	Observed protocol				
		Performed under supervision				
		Authorised to perform unsupervised				
	4.	Observed protocol				
		Performed under supervision				
		Authorised to perform unsupervised				

APPENDIX 8: RPS Radiation Bin Procedure

In the WHG Solid radioactive waste goes in a green bin with a yellow strip and we use a yellow bin sheet. Organic liquid radioactive waste goes in an orange bin and we use an orange bin sheet.

Each **SOLID WASTE RADIATION BIN** must be closed when **one** of the following is identified by the RPS:

- The bin cumulative activity reaches 37MBq
- The bin is ¾ filled
- The surface dose rate of the bin is 5uSv/h
- The first entry on the bin sheet is almost 12 months from the current date

Each **ORGANIC LIQUID RADIOACTIVE WASTE BIN** must be closed when **one** of the following is identified by the RPS:

- The bin cumulative activity for ^{3}H and ^{14}C reaches 3MBq
- The bin cumulative activity for ^{32}P, ^{35}S and ^{51}Cr reaches 0.9MBq
- The bin is ½ filled so as it is not too heavy
- The first entry on the bin sheet is almost 12 months from the current date

<u>The RPS must</u>:

Check the figures inputted by the radiation user and then complete the bottom section of the bin sheet.

Enter the bin number on both parts of the buff coloured label (supplied) and enter the totals for each radionuclide. They then enter the department (WHG), date, phone number and print their name and sign it.

Seal the black bag with the cable tie (supplied) and clamp the bin lid with the completed buff coloured label attached.

Monitor the bin for external contamination. If ^{3}H is being used in the room, wipe and scintillation counting will be needed, for other isotopes monitor the bin directly, if there are counts (this is likely if the contents are ^{32}P or ^{51}Cr) then a dry wipe presented to a monitor is needed.

Remove the magnetic trefoil warning sign.

Transfer the radiation bin to the radiation store. The door out to the bin compound from level 2 of HWBGM requires proximity card access. The radiation bin store is locked and the key is located at HWBGM reception.

Take a replacement bin of the same colour from the store. Enter the bin number returned and the bin number taken out of the store and the room number it is destined for on the sheet on the door of the store.

Return the completed bin sheet to the SRPS and obtain a new bin sheet for the replacement bin.

Place the black plastic sack (supplied) in the bin with the edge of the bag turned over the rim of the bin.

Place the magnetic trefoil warning sign on the side of the bin.

Write the bin number on the new bin sheet and place next to the bin.

APPENDIX 9: WHG Laboratory Rules

- **This is a Containment Level 2 laboratory as defined by ACDP**
- **Only authorized persons may enter and/or work in the laboratory**
- **Persons below the age of 16 must not enter the laboratory**
- **Lab coats & Safety Glasses must be worn at all times whilst working at the bench**

  Only exceptions are: *i* people passing through the labs, and *ii* where risk assessment has shown that PPE is not required in a specific area e.g. write-up benches
- **Other PPE must be worn where indicated on task-associated risk assessments**
- **Sensible footwear must be worn e.g. open sandals are not appropriate**
- **Never eat, drink, smoke, chew gum or apply cosmetics**
- **No storing of food or drink for human consumption is allowed**
- **Always wash your hands after laboratory work, using the hand wash basins provided**
- **All cuts and abrasions must be covered by a waterproof dressing**
- **Personal headsets must not be used in the laboratory**

  Radios are permitted but please consider the opinions of others working around you
- **All waste must be disposed of in accordance with the WTCHG policies**
- **All spillages must be dealt with appropriately**
- **All accidents and dangerous incidents must be reported**

  Accident/Incident book is located in reception
- **All laboratory workers must be aware of the guidelines set out in the WTCHG Safety Manuals**
- **No person should undertake work activities for which they have not been suitably trained**

WTCHG Health & Safety Officer

January 2011

APPENDIX 10: Risk assessment for use of electron microscopes

From

Ionising Radiations Regulations 2017; Regulation 7
Approved Code of Practice paragraphs 44 & 45

Hazards

External radiation hazard only. Low risk from low energy bremsstrahlung x-ray emissions. Less than 0.5 microsieverts per hour around the column. Not significant.

Achieving a vacuum for electron beam generation relies on correct assembly of components of column. Significant misalignment would render vacuum conditions unattainable. Minor misalignment possible and could result in a fine x-ray beam leaking from the column. Accidental exposures only foreseeable due to misalignment or damage to the column.

Exposed persons

Users, co-workers and those with unrestricted access to the laboratory.

Exposure throughout the course of a 2000 hour working year would not reasonably exceed 1 millisievert (the University dose investigation level). Exposures more likely to be of the order of only a few microsieverts.. Designation of classified workers unnecessary. Issue of personal dosimeters unnecessary.

Significant exposures due to misalignment not likely. Radiation monitoring required following any significant column maintenance or dismantling would identify any significant radiation leakage, assuming suitable monitoring instrument used i.e. Mini Instruments/Thermo 900 44B scintillation counter. Monitoring should therefore be performed by the service company on completion of the work. Where maintenance work is undertaken by the department, responsibility for monitoring rests with the department. If no suitable monitor is available, the Safety Office will attend site on request to perform radiation monitoring on completion of the work. Levels of radiation around the column are not significant if the instrument reading is less than half of full scale deflection.

Work practices

Equipment operated and maintained (including filament changes) in accordance with manufacturer's instructions without modification. Operation by competent and trained persons. Radiation survey around column following invasive maintenance procedures requiring dismantling of column. Significant maintenance carried out by equipment service engineers.

Access restriction unnecessary. Designation of controlled or supervised areas unnecessary.

Engineering controls, safety features and warning devices in place

None specifically for radiation protection purposes. Fabrication of equipment from low Z material minimised production of adventitious x-rays. Accurate column assembly required for vacuum generation minimising potential for x-ray leakage.

Administrative controls (written arrangements and access controls)

Simple written instructions required on safe operation of microscope; including the need for monitoring following significant maintenance events. Wearing of PPE for radiation protection purposes unnecessary. Access restriction not necessary on dose restriction grounds, including if pregnant (negligible foreseeable foetal doses).

Foreseeable incidents

Damage to column or incorrect column assembly following maintenance leading to x-ray dose rates greater than 0.5 microsieverts per hour. Equipment should be withdrawn from service until remedial action taken.

Training requirements

Departmental user training or supplier training will suffice. No specific training required on radiation safety grounds.

Information contained within this document will satisfy the IRR17 requirements to inform people of the health and safety risks associated with their work. Training should be documented.

Conclusion

Radiation risks associated with operation of an electron microscope are negligible. Exposures in excess of the University's investigation level (1mSv) are not reasonably foreseeable if the equipment is used and maintained in accordance with the manufacturer's operating instructions.

Actions required to ensure exposures will be as low as reasonably practicable:

- Equipment operated and maintained (including filament changes) in accordance with manufacturer's instructions by competent and trained persons.
- Equipment subject to routine service and maintenance.
- Radiation survey around column following invasive maintenance procedures requiring dismantling of column. Significant maintenance carried out by equipment service engineers.
- Equipment taken out of service pending remedial work by competent service engineers if radiation survey around column identifies accessible dose rates greater than 0.5 microsieverts per hour.

APPENDIX 11:

WRITTEN ARRANGEMENTS FOR WORK WITH URANIUM SALTS IN ELECTRON MICROSCOPY

wellcome centre human genetics

UNIVERSITY OF OXFORD

Division of Structural Biology (STRUBI)

Ionising Radiations Regulations 2017
Environmental Permitting (England & Wales) Regulations 2010 (as amended 2011)

NOTE: These arrangements are supplementary to the existing departmental local rules for work with radioactivity

Work with electron microscopes does not warrant any specific access control measures, but the associated use of uranium salts in powder form and solution require temporary designation of a supervised area. Such areas are required where work is usually of low risk but it is considered necessary to keep the working conditions under review on radiation safety grounds.

Persons responsible for supervision of these arrangements:
Senior Radiation Protection Supervisor (SRPS):

Dr Zuzana Bencokova Tel: 87787 Email: zuzana@well.ox.ac.uk

Radiation Protection Supervisor (RPS):

Dr Geoff Sutton Tel: 87685 Email: geoff@strubi.ox.ac.uk

The RPS is responsible for supervising the work with radioactive materials to ensure compliance with these Local Rules, the conditions of the EPA permits and relevant EPR exemption conditions (specifically relating to work with uranium and thorium compounds). Also ensuring that the radiation users in their groups are trained appropriately.

University Radiation Protection Officer (URPO):

Mark Bradley (URPO) Tel: 70802 Email: mark.bradley@safety.ox.ac.uk

1. These arrangements cover work in the STRUBI Electron microscopy room 00/97 and radiation room 00/76. They apply to work with uranium salts subject to the condition that the Uranium compound does not contain ^{235}U at a concentration greater than 0.72% by mass i.e. natural and depleted uranium but not enriched uranium. The advice of the URPO must be sought if this condition cannot be met.
2. Only registered radiation workers who have received specific training in the safe use of the Uranium compounds are permitted to use and prepare uranium stains for the purposes of electron microscopy. All registered workers have a Radiation worker training record (**appendix 6**). Safety Office radiation protection lecture (*Radiation Safety for Laboratory Workers- Open sources*) is recommended. All users should be familiar with the RSID 9 (Rev 2016/10)**:** Electron microscopy & associated use of uranium compounds.
3. Stocks of radioactive materials should be stored in a suitable radiation store when not in use. Stock and waste vessels should be distinguishable from one another and each clearly labelled with a radiation warning sign and legend "radioactive".

4. Records should be kept of the quantity (g) and location of radioactive materials. The combined atomic mass of uranium in all compounds held in the department as either materials or waste products must not exceed 2kg.
5. Appropriate PPE (gloves, lab coats and eyewear) should be worn during all work with unsealed radioactive materials. Dispensing should be carried out using appropriate handling tools.
6. Work with uranium stocks (e.g. initial preparation of stain) should be carried out within a fume hood room 00/76.
7. Work with uranium solutions prepared from the initial stock should be carried in the Lab 2 00/97 EM lab and in the OPIC EM Prep laboratory 10.12A.
8. Use of yellow stain is recommended. Identification of contamination would be more easily detected by the presence of a yellow stain.
9. Spill trays lined with benchkote where the spill can be quickly absorbed are used. The soiled benchcote spill would be dealt with as solid waste.
10. A calibrated and functioning contamination monitor (e.g. EP15) should be available and used throughout the work. On completion of the work, contamination measurements should be undertaken to confirm that there is no residual radioactive contamination. This should be recorded are recorded in the room 00/76 and 00/97 and 10.12A.
11. Solid radioactive waste generated by the experiment (including papers, filters, tips, tubes) should be placed in a plastic screw top container or in a black bag and stored within the radiation room. Full container or bag is disposed into general waste as soon as practicable. A record is kept of the quantity of radioactive waste in the store by mass (g) and date when disposed (see *Uranium Salts Subsequent Container or Sub-stock Record).*
12. The combined mass of stocks and accumulating U/Th radioactive waste in the department must not exceed 2 kg at any time; less than 500g of which should be accumulating waste. No individual waste container should store more than 100g uranium (atomic mass) in total. Arrangements must be made for collection by the Safety Office of radioactive waste by contacting Simon Haycox at radwaste@safety.ox.ac.uk.
13. Aqueous radioactive waste not exceeding a combined atomic mass of 5g uranium may be disposed of per week down a laboratory sink. Prior authority must be provided in writing by the URPO for any protocol or project that could generate quantities of aqueous waste in excess of 5g uranium per week. Aqueous waste should be flushed down the drain with large quantities of water. A record should be kept of every disposal of uranium to drain, recording the U isotope, mass in grams, link to the originating stock vessel, and the worker's initials.
14. Monthly returns should be made to the Safety Office of:
    a. The mass (g) of uranium held in stocks or prepared stains. "Mass" is the atomic mass of U/Th.
    b. Uranium disposals, using the standard aqueous waste disposal forms, but reported as waste atomic mass (g).

15. Emergencies

Anyone following good laboratory practices during work with electron microscopes or uranium compounds for EM staining could not reasonably approach the investigation level of 1mSv body dose. Nonetheless, the department and Safety Office will investigate any incidents that may lead to significant personal exposures. For example, a large spill/release of uranium stock material resulting in contamination of the laboratory or personnel. In the event of any incident or accident involving uranium compounds, the appropriate contingency plans **appendix 3** should be followed.

Uranium Salts *Subsequent Container or Sub-stock Record*

Record sheet to be used to record use and disposal of sub-stocks held in accordance with the Environmental Permitting (England & Wales) Regulations 2010 (as amended 2011)

Sheet to be kept for 2 years following disposal of radionuclide to which it refers.

Radionuclide: UA UFo UMgF	**Reference date:**
Container / ID number:	**Initial amount (mg)*:**
RPS:	**Initial volume made up (ml):**
Storage location:	**U concentration (mg/ml):**

Subsequent container or sub-stock						Waste arising		
(a) **User's name**	(b) **Date**	(c) **Stain No and volume of vials used**	(d) **No of grids stained**	(e) **Stain No and volume of vials remaining in the box**	(f) **Mass U in vials remaining in the box**	(g) **Volume to drain**	(h) **Mass U/Th to drains#**	(i) **Mass U/Th solid waste£**
		(total ml and No)	**(No)**	**(total ml and No)**	**(mg)**	**(ml)**	**(mg)**	**(mg)**

Notes:
* Total mass of U + Th held in the department (stocks + waste) must not exceed 2 kg.
# Total mass of U + Th disposed of to drain from the premises must not exceed 5g per week.
£ Total mass of U + Th disposed of from the department to the Safety Office as solid waste must not exceed 500g in any week.

Radionuclide Record Sheet (Uranium Salts) *Stock Record*

Record sheet to be used to record use and disposal of sub-stocks held in accordance with the Environmental Permitting (England & Wales) Regulations 2010 (as amended 2011)

Sheet to be kept for 2 years following disposal of radionuclide to which it refers.

Radionuclide: UA UFo UMgFo	**Reference date:**
Container / ID number:	**Initial amount (mg)*:**
RPS:	**Storage location:**

(A) User's name	(B) Date	(C) Mass dispensed (mg)	(D) Mass remaining (mg)	subsequent containers^ (E) ID number	(F) U/Th$ mass (mg)	(G) Volume$ made up (ml)	(H) Mass U to drains# (mg)	(J) Mass U solid waste£ (mg)

Date(s) container disposed to waste

Signature of RPS:

Notes:

*Total mass of U + Th held in the department (stocks + waste) must not exceed 2kg.

Total mass of U + Th atoms disposed of to drain from the premises must not exceed 5g per week.

£ Total mass of U + Th atoms disposed of from the department to the Safety Office as solid waste must not exceed 500g in any week.

$ Calculated quotient 8a/8b gives U or Th concentration (g/ml) for use on *subsequent container* record sheet.

^ Subsequent *containers* include sub-stocks, such as prepared stains, that will be maintained as a separate stock solution from which further aliquots will

APPENDIX 12: University of Oxford open radiation source risk assessment form.

Use of Uranium compounds in electron microscopy

Ref: OUSO/Risk1/EM-U-Th	Date: August 2017	
Department: *WHG* **Location of work:** *EM Room 673.00.97 676.10.12A, Fume Hood (Supervised Area) in 673.00.76*	**Persons involved** *Users of U compounds for microscopy*	**Others at risk** *Laboratory access restricted to names persons See the list of Authorized STRUBI users*

Description of procedure: *Use of prepared uranium compounds for electron microscopy*

Substance used	Quantities used (mg)	Frequency of use	Hazards identified	Exposure route	Dose per procedure (□Sv)
Uranyl acetate (U nat)	*Stock: Typically 50 g bottle* *Per assay: 5g for 5% stain 2g for 2% stain*	*1 x per year*	*α, β, γ* *External dose rate from U/Th stocks.* *Internal hazard from contamination by open sources & intakes.* *Very toxic, carcinogenic and mildly radioactive.*	whole body Y ~~/ N~~ skin Y ~~/ N~~ eyes ~~Y /~~ N inhalation Y ~~/ N~~ ingestion Y ~~/ N~~ absorption Y ~~/ N~~	*Whole body: < 1 μSv (exposures on intake may be considerably higher)* *Extremities and Eye: < 5 μSv*
Uranyl formate (U dep)	*Stock: Typically 50 g bottle* *Per assay: 5g for 5% stain 2g for 2% stain*	*3 x per year*	*α, β, γ* *External dose rate from U/Th stocks.* *Internal hazard from contamination by open sources & intakes.* *Very toxic, carcinogenic and mildly radioactive.*	whole body Y ~~/ N~~ skin Y ~~/ N~~ eyes ~~Y /~~ N inhalation Y ~~/ N~~ ingestion Y ~~/ N~~ absorption Y ~~/ N~~	*Whole body: < 1 μSv (exposures on intake may be considerably higher)* *Extremities and Eye: < 5 μSv*
Uranyl Mg acetate (U nat)	*Stock: Typically 2 g bottle* *Per assay: 5g for 5% stain 2g for 2% stain*	*1 x per year*	*α, β, γ* *External dose rate from U/Th stocks.* *Internal hazard from contamination by open sources & intakes.* *Very toxic, carcinogenic and mildly radioactive.*	whole body Y ~~/ N~~ skin Y ~~/ N~~ eyes ~~Y /~~ N inhalation Y ~~/ N~~ ingestion Y ~~/ N~~ absorption Y ~~/ N~~	*Whole body: < 1 μSv (exposures on intake may be considerably higher)* *Extremities and Eye: < 5 μSv*

Could a less hazardous substance (or form of the substance) be used instead? ~~Yes /~~ No

Justify not using it: *Alternative non-active substances, such as Pt-Blue, OTE, $KMnO_4$ and PTA, are available but studies such as that found at http://www.ncbi.nlm.nih.gov/pubmed/19767626 have concluded that none of the reagents examined showed staining results of the same quality or better than the conventional method with uranium.*

Could a lower activity be used? ~~Yes~~ / No

Justify quantity of material in use: *Mass of material used determines quantity of stain that can be prepared at the required percentage concentration. Prepared stain solutions are aliquots, retained and used over extended periods after preparation*

What measures have you taken to control risk?

Engineering controls & safety equipment: Main consideration is control of contamination; particularly airborne contamination by powder stocks of alpha-emitting isotopes. Work in drip trays. Dispensing from powder stock bottles performed within fume hood/contained workstation. Staining grids by pipette from sub-stocks performed within drip tray over absorbent material. No sharps required. EP15 contamination monitor used throughout.

PPE: Lab coat fastened to neck with elastic cuffs. Nitrile gloves. Safety eyewear.

Procedural & management controls: Designation of fume hood as supervised area during stock and aliquoting operations. No other work in hood. Restrict non-essential access to lab during work with radioactive stocks. Work in accordance with written arrangements in departmental local rules. Good laboratory practice prohibits eating, drinking, chewing etc in laboratory. Contamination monitoring with EP15 before, during & after procedure. Immediate decontamination of spills to B/G (wipe up powder spills with moist cloth and dispose; absorb liquid spills with paper towel and dispose). Fixed contamination noted and advice sought from RPS. Monitoring recorded. Stock, use & solid/aqueous waste records kept. Stock & waste limits assigned in local rules.

Checks on control measures:

RPS supervises laboratory. SRPS approval required for all orders of stocks in accordance with document SOP1. Contamination monitoring of work areas throughout work. Results recorded. Fume hood checked before use. Faults reported. Annual fume hood check. Work practices reviewed during departmental safety inspections. Work practices reviewed during periodic radiation safety inspections by the University Safety Office.

Radiation monitor:	*Mini 900 EP15 contamination monitor*	**Training requirements:** *URPO document "Radiation safety in electron microscopy" Laboratory induction At-bench training by experienced user / RPS Mentoring until competence demonstrated*
Is dosimetry required?	~~Yes /~~ No	
Type of dosimetry:	~~Extremity / Whole body / Biological~~	

Emergency procedures:

Reasonably foreseeable incidents identified in departmental laboratory local rules are relevant to work with open sources of U compounds. In the event of spill of powder stock, close hood and contact SRPS. Contingency plans in local rules are appropriate.

Decontamination procedures:

See contingency plans in departmental local rules and appendix 16 of S8/05

Waste disposal:

Solid (%): *100 %* (must not exceed 5g per day)

Aqueous (%): *0 %* (must not exceed 5g per week)

Organic liquid (%): 0

Gaseous (%): 0

Are overall risk control measures adequate?	**Yes ~~/ No~~**	**Signature:**
Name & position of assessor:	**Zuzana Bencokova (SRPS)**	**Signature**:
Name of radiation protection supervisor:	**Geoff Sutton (RPS)**	**Signature**:

Date of routine review	Date:	/ / 2017	/ / 2018	/ / 2019	/ / 2020	/ / 2021
	By:					

Dose estimates:

External doses from Uranium stocks: Dose rates in contact with Uranium compound stock vessels may be of the order 50 microsieverts per hour but they are typically significantly lower. If it is pessimistically assumed that preparation of the stain requires handling the stock vessel for 5 minutes, this will result in an extremity dose of less than 5 microsieverts. Dose rates in contact with the vessel containing the prepared stain solution are negligible and subsequent external exposures can reasonably be ignored. If the stipulated PPE is worn, skin contamination can reasonably be discounted. However, significant skin doses from personal contamination are not foreseeable, particularly if contamination is promptly identified by the vigilant use of contamination monitoring equipment. The accessible radiation dose rate at 30cm from the stock vessel is not significant and whole body exposures can therefore be discounted.

Internal exposures from intakes of uranium compounds: Assuming the preparation requires the weighing of 5g of Uranyl acetate (i.e. approx 3g ^{238}U atoms), then according to Delacroix data:

- Inhalation of approx 10mg of Uranyl Acetate (or 2% of the dispensed quantity of powder assumed for the purposes of this assessment) would result in a committed effective dose of 1 mSv, which is equivalent to the University's investigation level for open source work. The requirement that work with powder stocks is carried out inside a functioning fume hood should prevent any inhalation.
- Ingestion of approx 3g of Uranyl Acetate (60% of the dispensed quantity of powder assumed for the purposes of this assessment) would result in a committed effective dose of 1 mSv. The adoption of good laboratory practice and vigilant use of suitable PPE and contamination monitoring equipment should minimise the risk of intakes through ingestion. Nonetheless, an intake of 3g of the radioactive stock is not considered reasonably foreseeable throughout the year.

Procedures to minimise intakes of radioactivity or personal contamination are contained in the departmental *written arrangements for work with uranium salts in electron microscopy*.

Potential foetal exposures: The IRR17 require that the exposure of a foetus must not exceed 1 mSv during the term of pregnancy between declaration and birth. It is not reasonably foreseeable that external exposures during use of Uranium compounds in electron microscopy could give rise to significant exposure of the maternal abdomen.

As explained above, significant intakes of radioactivity or personal contamination likely to give rise to a maternal exposure

of 1 mSv are not considered reasonably foreseeable if departmental arrangements are followed. Since uranium is not preferentially taken up by the foetus in comparison to maternal uptake, the foetal dose would not therefore exceed 1 mSv exposure restriction level specified in IRR17.

It is not considered necessary on the basis of radiation risks to the foetus to alter the working conditions of a pregnant/breastfeeding worker. However, if the work (in particular the preparation of stains) can be carried out by another worker during pregnancy/breastfeeding it would be prudent to do so on the basis of ALARP and to ensure complete reassurance.

Investigation level: The University has set an investigation level of 1 millisievert effective dose. Any exposures above this level will be investigated by the department and URPO to determine whether everything is being done that is reasonably practicable to restrict exposures or whether more can be done. In practice, the academic supervisor/Radiation Protection Supervisor should be informed of any incidents that may lead to significant personal exposures; for example, a significant spill/release; widespread contamination or personal contamination. Such incidents will be investigated.

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* Ref: HSE Contract research report 397/2001: *Doses to the embryo/fetus and neonate from intakes of radionuclides by the moth*

APPENDIX 13: WRITTEN ARRANGEMENTS FOR WORK WITH FAXITRON X-RAY IRRADIATOR

Ionising Radiations Regulations 2017

UPS 1/12 Revised Dec 2017: Management of Work with Ionising Radiation at the University of Oxford

NOTE: These arrangements are supplementary to the existing departmental local rules for work with radioactivity.

Persons responsible for supervision of these arrangements:

Senior Radiation Protection Supervisor (SRPS):

Dr Zuzana Bencokova Tel: 87787 Email: zuzana@well.ox.ac.uk

Radiation Protection Supervisor (RPS):

Dr J. Ross Chapman Tel: 87839 Email: ross.chapman@well.ox.ac.uk

The RPS is responsible for supervising the work with radioactive materials to ensure compliance with these Local Rules, the conditions of the EPA permits and relevant EPR exemption conditions (specifically relating to work with uranium and thorium compounds). Also ensuring that the radiation users in their groups are trained appropriately.

University Radiation Protection Officer (URPO):

Mark Bradley (URPO) Tel: 70802 Email: mark.bradley@safety.ox.ac.uk

Designation of areas

No controlled or supervised areas are designated during routine use of the x-ray irradiator in accordance with manufacturer's instructions since inherent engineering controls (incl. shielding) and safety features (e.g. safety interlock devices) effectively prevent access to the inside of the enclosure where high radiation dose rates exist during operation.

Investigation level

The University has set a dose investigation level of 1 mSv body dose. External whole body exposures above this investigation level are not reasonably foreseeable during x-ray irradiation since accessible radiation dose rates in contact with the body of the device do not exceed 1 μSv per hour and workload will not approach 1000 hours during a year.

Written arrangements for X-ray irradiation work

1. These arrangements cover work with the Faxitron X-ray irradiator currently located in the room 10.143A Lab 4S.
2. The University has set a dose investigation level of 1 mSv body dose. External whole body exposures above this investigation level are not reasonably foreseeable during x-ray irradiation since accessible radiation dose rates in contact with the body of the device do not exceed 1 μSv per hour and workload will not approach 1000 hours during a year.
3. Only registered radiation workers who have received specific training in the safe use of the equipment and these Local Rules are permitted to use the X-ray cabinet. Safety Office radiation protection lecture (*Safe Use*

of X-ray Generators, Sealed Sources & Accelerators) is recommended. All registered workers have a Radiation worker training record (**appendix 6**).

4. Equipment should be operated in accordance with manufacturer's instructions and user training provided by the department. No attempt must be made to override or tamper with the equipment's safety features or warning devices.

5. The RPS shall ensure that the key is kept securely and is only accessible by authorised users. The key must not be left in the equipment and should be returned to storage after use.

6. If you consider that you might have received a radiation exposure *greater than expected* notify the SRPS, informing them of the circumstances of the potential exposure e.g. operating parameters, proximity, duration of exposure, etc.

7. The RPS should be notified of any suspected fault with the equipment or its safety features. In the event of a fault, the equipment should be taken out of service until it has been repaired by the service engineers and a radiation safety check has been undertaken confirming that it is safe to bring back into service.

8. A termly check must be performed of the equipment safety features using the form in the **appendix 14** to the local rules. Dose rate measurements will be made during the URPO's periodic radiation safety inspections of the Centre.

9. Emergencies

Anyone following good laboratory practices during work with Faxitron X-ray generator could not reasonably approach this investigation level of 1mSv body dose. Nonetheless, the department and Safety Office will investigate any incidents that may lead to significant personal exposures. In the event of any incident or accident involving X-ray irradiator, the appropriate contingency plans **appendix 3** should be followed.

APPENDIX 14: FAXITRON TERMLY SAFETY CHECKSLIST

Failure of any of checks 3-7 should be brought to the attention of the RPS. The equipment service engineers should be contacted to correct the fault. In the event of failure of checks 5-7 the set should be immediately taken out of service.

FAXITRON TERMLY CHECKS	**Test result # (& initials)**											
Date												
1. Warning signs present & visible												
2. Local rules posted												
3. Power on light function												
4. X-ray ready light function												
5. X-ray on light function												
6. Door interlock function*												
7. Emergency off switch												
CPS values when using Thermo 42A/44A for checking door interlock function.												

A “tick” means a check was made and the safety feature performed adequately. A “cross” means a check made and safety feature failed. A “dash” means no check was made.

* The door interlock function should be tested by setting the device at lowest possible kV and mA and whilst standing behind the door of the device. Whilst holding a scintillation detector (e.g. Thermo 42A/44A) at the door edge, an attempt should be made to gently ease the door open. X-ray generation should terminate before the door can be opened more than a few millimetres. If x-rays do not immediately terminate, the door should be reclosed, the key removed, and the advice of the RPS sought urgently.

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