Imperial College London

Safety Department
Imperial College London
radiation.protection@imperial.ac.uk

Work Reg. ID / RIP No: (RPA/RPO Use Only.)	RSR-24-2019	Applicants Own Unique Ref No.	SciWire-QA-RP-01

Risk Assessment, Regulation 8 of the Ionising Radiations Regulations 2017

Work Registration Form J - Radiological Risk Assessment

Please complete all sections:

J1. Description of Process and Scope of PRA

This work project involves detector characterisation measurements of the SciWire scintillating fibre detector. Using a 3.7MBq Sr^{90} beta-emitter, characterisation measurements will be carried out. The beta-emitter will be attached to a motorised translation stage using a cylindrical source holder.
The stage will be used to scan the source across the surface of the SciWire detector whilst data is read from the detector.
The experiment will take place within a light-tight box that is fixed to an optical table with a lid that is secured (by padlock) to the body of the box. The home position of the translation stage will place the open end of the collimator within a housing that will effectively close off the source.

This risk assessment has been completed in accordance with the Ionising Radiations Regulations (2017). The risk assessment ONLY considers the radiological aspects of this work and further assessment will be needed to cover the other hazards that may be present (e.g. biological and COSHH).

Heads of Department, Principal Investigators, Radiation Protection Supervisors (RPS) and users must comply with College Policy and Guidance relating to work with ionising radiations. Policy & Guidance for work involving ionising radiations can be found on the Safety Department Web Pages at:

- **Ionising Radiations Policy** - https://www.imperial.ac.uk/safety/safety-by-topic/laboratory-safety/ionising-radiation-safety/radiation-safety-policy/
- **Ionising Radiations Guidance** - http://www.imperial.ac.uk/safety/safety-by-topic/laboratory-safety/ionising-radiation-safety/

J2. Identification of Exposed Personnel and Exposure Pathways

Nature of the sources of ionising radiation:
Sr-90. This is a beta-emitter with a half-life of 28.2 years and maximum energy of 2284keV. The sealed source is collimated with a nominal activity of 3.7MBq, current activity just under 1.7MBq.

The experiment will involve transferring the source from the 5th floor lab to lab 527 on the same floor within Blackett Building, installing it within the experimental set-up and de-installing and returning the source to the source storage.
Potentially the project may involve adjustments to the experimental set-up.

Description of quantification of likely EXTERNAL radiation exposure pathways (including routine and reasonably foreseeable accidents and "other persons" (i.e. staff not involved in work with ionising radiations and members of the public)):

Operation
The source will be transferred inside a fully shielded container, ready for installation.
The external exposure from a Sr-90 point source with 1.7MBq activity, would be 0.35mSv/h at a distance of 30cm, if the source was inadvertently directed at the user. Assuming installation and de-installation takes five minutes each, the dose to the researcher during the experiment duration would be ~0.06mSv.

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Since the source is collimated, one end is suitable for handling. This was confirmed by monitoring of the source. A RadEye 20B (SN 01645) with H'(07) beta filter was used for the monitoring, to determine dose rate at the handling end.
Background in the lab read as 0.00012mSv/h. The top and side on the non-collimated end gave readings of a maximum of 0.0064mSv/h (25cps without the H'(07) filter). This would result in a dose of ~ 0.001 mSv to the hands, if we assume installation and de-installation take five minutes each.
This experiment will run as a one-off, therefore installation and de-installation will only happen once each.

Once installed, the housing (>5mm of aluminium) will provide sufficient shielding to fully stop the beta particles. Based on 'Introduction to Health Physics', 4th Ed., H. Cember, T. E. Johnson, Figure 5-3. Range-energy for beta particles in various substances, 5mm of aluminium provides full shielding up to energies of 2.5MeV.

As long as the source is parked in the home position within the housing, adjustments to the other parts of the experimental set-up should not cause any significant exposure to the researcher. Based on the monitoring, doses would be less than 0.01 mSv to the hands, even if working close to the non-collimated end of the source for an hour.

Correct handling, with the collimated beam end pointing away from the researcher, is essential to keep doses as low as reasonably practicable.

Since the experiment is a one-off, the total annual dose to the researcher from this work registration will be <1mSv per year.

Incidents/accidents
Hand in source beam
If the Sr-90 source was accidentally handled directly (assumed as a distance of 1mm) for ten seconds, this could lead to a beta skin dose of ~103mSv. However this is unlikely to occur, if the instructions from the risk assessment are followed.
Leaking source
Taking potential accident scenarios into account the possibility of skin exposure from contamination due to a leaking source is considered. If we assume 1% of the activity is released or transferred and 1% comes into contact with skin, due to a leaking source, the dose rates would be from a single event.
The leaked Sr-90 1.7MBq source would result in a leaked activity of 0.0017MBq, if this was left on exposed skin for 10 minutes the skin dose would be 0.055mSv.

To reduce the likelihood of this occurring, contamination monitoring should be carried out before and after installation and de-installation. We recommend that disposable gloves are worn when handling the source.

Description and quantification of likely INTERNAL radiation exposure pathways (including routine and reasonably foreseeable accidents and "other persons" (i.e. staff not involved in work with ionising radiations and members of the public)):
Due to their construction sealed radioactive sources typically will not pose a risk of internal hazard unless the source is damaged and has removable activity or the source is destroyed by fire and there is a release of material.
Both these accident scenarios will be considered for the calculated Committed Effective Dose (CED) from the internal ingestion and inhalation hazard.

Work Reg. ID / RIP No: (RPA/RPO Use Only.)	RSR-24-2019	Applicants Own Unique Ref No.	SciWire-QA-RP-01

- **Scenario 1**: The sealed source is leaking or damaged and removable activity is present to pose an ingestion and inhalation hazard dose from a single event.
  Ingestion Assumptions:
  It is assumed that the researcher remained in the laboratory near the source for a maximum of 10 minutes (600 seconds) after leak, 10% of the material is released, 10% of which is ingested.

Radioisotope	Activity Ingested (1%)	*DPUI (Ingestion) (Sv/Bq)	CED
Sr-90	0.017MBq	2.8x10-8	0.476milliSv

*Dose per Unit Intake (DPUI)

Inhalation Assumptions:
It is assumed the volume of the laboratory is 26.6m3, floor footprint 11.1m2 and standard room height, the breathing rate for an adult is 0.00033m3/s and the initial airborne concentration is calculated, as 10% of the source activity released over the volume of the laboratory and 10% is respirable.

Radioisotope	Activity Released (10%)	IAC* (Bq/m3)	TIAC** (Bq/m3)	DPUI (Sv/Bq)	CED***
Sr-90	170000Bq	639.1	383458.6	3.0x10-8	0.0038 milliSv

*(Initial Airborne Concentration = 10% of activity released, divided by the volume of the room and 10% is respirable).
**(Time Integrated Air Concentration = IAC x Time of exposure in seconds).
***(Committed Effective Dose = TIAC x Breathing Rate x DPUI).
Total Doses (Ingestion + Inhalation) ~ 0.5milliSv.

- **Scenario 2**: The sealed radioactive sources are destroyed by fire, with an ignition source from a single event.
  Fire Assumptions:
  For the sources involved in the fire assume 1% is released and 10% of that activity is respirable.
  It is assumed the researcher stays in the room only for 1 minute.
  The CED for Inhalation is below.

Radioisotope	Activity Released (1%)	IAC (Bq/m3)	TIAC** (Bq/m3)	DPUI (Sv/Bq)	CED***
Sr-90	17000Bq	63.9	3834.6	3.0x10-8	0.038microSv

The total CED for Inhalation to the researcher is ~0.038microSv.

For a Fire Fighter without any respiratory protection entering the laboratory for 15 minutes (900 seconds) the CED would be ~0.6microSv.

Results of previous personal dosimetry or area monitoring:
Not available.

Is the annual effective (internal + external) dose likely to exceed 1mSv per year?	☐ Yes ☒ No

J3. Safeguards

Advice from manufacturer or supplier of equipment or materials:
Not available

Engineering control measures and design features:

- Collimated source, constructed to reduce handling dose
- Shielding in the form of 5mm enclosure, to be padlocked to prevent accidental or malicious

Work Reg. ID / RIP No: (RPA/RPO Use Only.)	RSR-24-2019	Applicants Own Unique Ref No.	SciWire-QA-RP-01

removal of the source
- Lab is access controlled (pin pad access) to prevent unauthorised personnel entering
- Home position of the source will place source within housing

Relevant systems of work, permits, local rules or written arrangements:

Correct handling, with the collimated beam end pointing away from the researcher, is essential to keep doses as low as reasonably practicable.
A Standard Operating Procedure (SOP) is in place for the safe use of the radioactive source and this specifies the requirement for contamination monitoring and safe handling.
The work is covered by the existing local rules for working with the sources.

Manipulation of the sealed radioactive source should be conducted wearing nitrile gloves.
Contamination monitoring with a Mini-Monitor 44B will be carried out at installation and de-installation or any other incidences, where the source must be accessed or moved. This is to ensure that the source is not leaking.

To carry out contamination monitoring, monitor the source holder before the source goes in, to establish background. Then monitor the source holder again, when the source has been removed to make sure that it remains free from contamination and that the source remains intact.

The equipment should be marked with a trefoil and the word 'radioactive'.
Additionally a warning sign, to contact the RPS before moving the equipment, should be affixed to the equipment.

Effectiveness and suitability of personal protective equipment:
Disposable gloves should be worn during handling of the source.

J4. Contingency Plans

*Comprehensive contingency arrangements covering all reasonably foreseeable incidents must be detailed in the **Local Rules**. It is imperative that all workers are familiar with these and understand them before they begin work.*

Reasonably foreseeable incidents that have been identified, together with recommended actions, include *(insert list of reasonably foreseeable incidents and actions etc)*:

The following credible incidents have been identified:
Damaged sealed source leading to a contamination hazard
Researchers working in the laboratory will adopt methods and precautions to minimise the risk of a damaged source occurring and when this does, limit its severity. This includes removing persons present in the area, using secure containment.
If contamination occurs:
1. Secure the immediate area.
2. Ensure no researchers are in the immediate vicinity.
3. Call the Radiation Protection Adviser (RPA)/ Radiation Protection Officer (RPO).
4. The RPA/RPO will help with advice on de-contamination using appropriate radiation protection principles.

Dropped or lost source (e.g. falls on the floor and rolls out of sight)
1. Use a Mini 900 44B Scintillation monitor to attempt to detect and locate the source
2. When the source is found, inspect the source carefully for physical damage before recovering

Work Reg. ID / RIP No: (RPA/RPO Use Only.)	RSR-24-2019	Applicants Own Unique Ref No.	SciWire-QA-RP-01

the source.

3. If the source is suspected of being damaged, then follow the contamination procedure.

Where a sealed radioactive source is suspected of being lost or stolen

The following actions must be carried out:

1. Attempt to search the laboratory to find the missing source.
2. Use retained photographs and data on the source to help the search.
3. If this is unsuccessful report the missing source on the Local Records.
4. Contact the RPA/RPO as soon as possible so an investigation can be conducted.
5. Inform College Security.

If immediate investigations by the RPA/RPO do not lead to the subsequent recovery of the sealed radioactive source, then the RPA will notify the Regulator and the Police at once.

Fire Alarm

Follow Imperial College Fire Safety Procedures. Secure the source if it is safe to do so. Take note of the location and details of all radioactive sources and ensure this information is communicated to the relevant personnel, by following the instructions in the ERP, once the building has been evacuation.

Flood

Isolate any electrical equipment in the affected area from the electrical supply if it is safe to do so. Place all sources back into storage and ensure they are secure and suitably contained. Leave and secure the area and report using normal College systems.

If any of the incidents detailed above do occur, they must be reported via normal College reporting systems: SALUS

J5. Designation of Work Areas

Describe any requirement for Controlled or Supervised Areas and the suitability of identified areas:

Under normal operating conditions no dose above the public dose limit. Therefore, no designation of the area required.

J6. Personal Dosimetry Requirements

Whole Body (Quarterly)	Whole Body (Monthly)	Neutron (Quarterly)	Extremity (Quarterly)	Extremity (Monthly)	Thyroid	Other
N	N	N	N	N	N	N
RPA/RPO Comments		Under normal operating conditions no dose above the public dose limit. Therefore, no personal dose monitoring required.				

J7. RPA/RSO Recommendations

Registration-specific recommendations:

The following procedures are required to use the sealed radioactive source.

- Correct handling, with the collimated beam end pointing away from the researcher, is essential to keep doses as low as reasonably practicable.
- Localised shielding must be used to reduce the possible external radiation doses from the sources.

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- A Mini-series 900 with 44B Scintillation radiation monitor must be used to confirm presence of the sources and to confirm the absence of contamination.
- Access to the sealed source must only be by authorised persons.
- The sealed source must be promptly returned to their storage cabinet on the 5th floor, when no longer in use.
- A warning sign to contact the RPS before moving the equipment should be affixed.
- A Standard Operating Procedure (SoP) must be in place to instruct researchers on the safe use of the sealed radioactive sources during experiments.

Generic recommendations:

- All radiation users must be registered with the Safety Department and have completed a Personnel Registration Form.
- The findings of this risk assessment must be made available to researchers under RSR-17-2019.
- All radiation users must have completed the Radiation Protection e-learning (module 1) as part of the Personnel Registration process.
- The work must be supervised by the Laboratory Manager, to ensure the sources of ionising radiations are controlled and managed.
- Radiation signage with BS Standard radiation trefoils will be placed on the equipment, which holds the source.
- The radiation monitor must be maintained and calibrated every 12 months and a certificate of calibration kept until the instrument is tested again.
- Notifications or Near Misses, Dangerous Occurrences and Accidents using ionising radiations must be reported to the Lab Manager and the College RPA or RPO.
- Radiation monitoring records should be kept for a minimum of 2 years.

J8. RPA / RPO Approval

It is recommended that this work can proceed. Approval is conditional upon the information provided being accurate and the RPA/RPO recommendations being complied with.

RPA / RPO	Name	Signature	Date
Prepared by: RPO	Gwen Mott	G. Mott	16/08/2019
Approved by: RPA	Ross Manson	RS. Manson	16/08/2019
Relevant RPS /Lab Manager/PI	**Name**	**Signature**	**Date**
Accepted by: RPS/Lab Manager	ANTONIN VACHERET	*Type name or print off and sign*	12/09/2019
Accepted By: PI	Kenneth Long	*Type name or print off and sign* Kenneth Long	16Sep19
Work Registration No.	RSR-24-2019	Date of Review:	