University of St Andrews

Risk Assessment No 8 - Risk Assessment for the Use of Radiation Generator Equipment HSE Registration Under the Ionising Radiations Regulations 2017

Ionising Radiations Regulations 2017

Document type	**Procedure**
Scope (applies to)	Staff and students
Applicability date	11/07/2021
Review / Expiry date	11/07/2024
Approved date	12/07/2021
Approver	Head of EHSS
Document owner	Deputy Director
School / unit	Environmental Health and Safety Services
Document status	Published
Information classification	Public
Equality impact assessment	None
Key terms	Health and safety/Hazard identification and risk assessment
Purpose	Compliance with Ionising Radiations Regulations 2017 legislation

RISK ASSESSMENT 8 - Risk Assessment for the Use of Radiation Generator Equipment - HSE Registration under the Ionising Radiations Regulations 2017		
Location		
Building : **Room Number**		
Details of Equipment		
Name of Equipment:	**kV:**	**Serial Number**
Name of Equipment:	**kV:**	**Serial Number**
Name of Equipment:	**kV:**	**Serial Number**
Name of Equipment:	**kV:**	**Serial Number**
Description of Work and Scope of the Assessment **Use of X-ray crystallography equipment for studying the structure of chemicals and biological chemicals as well as the use of XRF machines to determine fluorescence in geological samples.** **This risk assessment ONLY covers work inside cabinets/enclosures which are closed and interlocked such that there is no access to the X-ray beam.** **Beam alignments that can be undertaken by external software to the equipment and do NOT require the interlocks to be bypassed can use this risk assessment.**		
This risk assessment has been carried out in accordance with the Ionising Radiations Regulations 2017 (IRR17) Approved Code of Practice (ACoP). This risk assessment only addresses the radiological risks associated with the type of equipment detailed above.		
Who is at risk?		
Operator - All X-ray beams are in cabinets or enclosures behind interlocked x-ray shielding.		

ACoP Paragraph 70 - Matters to be considered in an assessment, where relevant

70(a) - Nature of the radiation sources likely to be present

Equipment is designed to produce X-rays for crystallographic or powder analysis. The X-ray sources behind shielding which is fully interlocked to cabinet or enclosure such that there is no access to an active X-ray beam.

Where alignment of the beams can be undertaken by software external to the equipment and does **NOT** require the interlocks to be bypassed, is included within this risk assessment.

70(b) - Estimated dose rates

Do For radiation protection the x-ray output of a tube can be divided into three components as follows.

(i) **Main beam radiation:** Radiation dose-rates in the collimated main beam can be up to about 5 Grays/second, exposure to which can lead to overexposure of and in some cases serious injury to skin, immediately underlying tissues and eyes depending on absorbed dose and area irradiated.

(ii) **Scattered radiation:** Radiation dose-rates due to unshielded scattered radiation can be of the order of tens of milliGrays in close proximity to the x-ray output.

(iii) **Radiation emitted from tube other than in main beam:** With a tube shield in place this radiation is very substantially shielded and is referred to as "tube shield leakage radiation". Shields are manufactured so that the dose received in an hour at 1 meter from the tube will not exceed 1 microGray.

The dose from a direct X-ray beam is derived from the calculation:

$$\frac{0.5 \times V \times I \quad \text{grays/s}}{D^2}$$

Where V = Voltage (kVp), I=Current (mA) with 1mm beryllium filtration, D = Distance from tungsten target (cms)

In normal operation dose of radiation a fully exposed X-ray beam is approximately 5 Grays/sec or more (given slight variations in different equipment). There is also risk of scattered X-ray radiation which may affect the operator.

This risk assessment deals with the potential risk outside interlocked shielded cabinets or enclosures. Any work which requires interlocks to be bypassed is dealt with Risk Assessment **No 9 X-Ray Beam Alignment Risk Assessment for the Use of Radiation Generator Equipment where Interlocks have been bypassed.**

Measurements are regularly taken on the outside of the cabinets and no dose above 2.5 μSv/hr can be measured when the interlocked shielding is in place. The cabinet/enclosure will be regularly monitored using a dose rate meter or a scintillation probe contamination monitor. Where the readings are 3x above background, then it will be deemed there is X-ray leakage through the cabinet. Where there is evidence that there is leakage of X-rays - the machine will be deactivated by pressing the emergency stop and then powering down. The equipment will be taken out of service until a specialist maintenance engineer has fixed the issue.

There is no evidence of scattered X-ray radiation penetrating the shielding due to data from whole body dose readings that no worker has received a dose greater than 0.1 mSv/2 month period.

The main beam however could produce a dose of approximately 5 Grays/second thus potentially could cause a serious injury.

Any work by a maintenance engineer which requires the interlocks being bypassed will require the room to be managed by the company and **NO University staff** can be present under this risk assessment (anybody present must work under Risk Assessment No 9 X-Ray Beam Alignment Risk Assessment for the Use of Radiation Generator Equipment where Interlocks have been bypassed). The management of the room should be handed over to the company using the form as given in Appendix 1. The company should produce a suitable System of Work which has been approved prior to the work starting by the local DRPS and URPO

70(c) - Likelihood of contamination arising and being spread

None

70(d) - Results of previous personal dosimetry and area monitoring

No doses as measured on whole body dosimeter are greater than 0.1 mSv/2 months for normal use of the equipment. Dose rates measured outside the shielding of greater than 2.5 μSv/h outside the shielded cabinet or enclosure.

70(e) - Advice from manufacturers or suppliers about safe use and maintenance of equipment

No person will be bypassing the interlocks of the X-ray machine using this risk assessment (such work is undertaken under **Risk Assessment No 9 X-Ray Beam Alignment Risk Assessment for the Use of Radiation Generator Equipment where Interlocks have been bypassed**). Only named authorised personnel will be allowed to load samples into the equipment as stated on the RadProt Programme. Any required maintenance will be carried out by manufacturer. All such maintenance requires the room management to be handed over to the contractor using the form in Appendix 1. Details of manufacturers safe use of equipment can be found at URL: ??????????????????????????????

Where **work is done on equipment where the interlocks have been bypassed** must require the room to be designated as a 'Controlled Area' under a System of Work and with the following signage on the door:

70(f) - Engineering Controls, etc. In place or planned

To avoid accidental activation of the X-ray equipment when it is being set up, the keys which allow the power source to be activated must be removed and stored away from the equipment.

The X-ray device is shielded by cabinet or enclosure to attenuate all leakage/scatter radiation from cabinet. Interlocks are linked to shielding on cabinet or enclosure such that X-ray beam is shuttered or stopped or switched off if interlock broken.

There are emergency shutter block buttons installed in all enclosure machines. Where there is evidence of X-ray leakage through the shielding, the emergency stop button must be pressed, the equipment depowered, key to the power supply removed and the door to the room locked.

The X-ray cabinet /enclosure will be regularly monitored for radiation dose or measured using a scintillation probe contamination monitor. Any reading which is 3x background should be identified as leaking X-ray radiation and the machine switched off using the emergency stop and then depowered

70(g) - Planned Systems of Work

The inside of the X-ray equipment will be deemed a 'Controlled Area' and all such areas will be marked with the signage:

Thus when loading samples into the machine and there is **NO** active X-ray beam, you will still require a System of Work which needs to be produced showing the process of loading a sample and what precautions are needed to ensure there is no potential exposure to the X-ray beam - see Appendix 2

70(h) - Estimated airborne and surface contamination levels

None.

70(i) - Effectiveness and suitability of PPE

None required. Only general laboratory personal protective equipment, ie Laboratory coat, eye protection and if necessary, disposable nitrile gloves

70(j) - Unrestricted access to high dose rates or significant contamination

No high dose X-rays present. All X-ray beams behind interlocked shielding for routine work. Regular measurements will be undertaken to ensure the shielding is effective. If there is evidence of radiation leakage from the shielded cabinets/enclosures (3x background), the emergency stop button will be activated, the equipment powered down and room closed and locked. A specialist engineer will then be called out.

70(k) - Possible accident situations, their likelihood and severity

The X-ray beam does not terminate at the end of exposure and remains active when the interlocks are broken. In such circumstance the the emergency stop button will be activated, the equipment powered down and room closed and locked. A specialist engineer will then be called out. Warning lights must show beam still active.

See Table 1. The possible accident would be that:

> A shutter does not operate when the interlocked door opens thus there is still an active beam exposing the operator to a significant dose of radiation.

The consequences of this could be severe radiation burn if somebody put their hand in the active beam.

70(l) - Consequences of failure of Control Measures including Systems of Work
See Table 1
70(m) - Steps taken to prevent accidents, or limit their consequences
Only staff who have been suitably trained on the use the particular equipment by the manufacturer or supplier will be allowed to use the equipment. All such staff will also have to attend the ARPS X-Ray radiation Awareness Course There should be no exposure to the X-ray beam as it is behind interlocked shielding. There are also lights within the equipment to identify when the X-ray beam is active. These lights should change to show that the X-ray beam is either switched off or a shutter is released. A diagram of what the lights mean within the equipment is posted in the room with X-ray equipment. See Table 1. All interlocks tested on a regular basis. Radiation levels are measured on a regular basis using a dose rate meter or a scintillation probe contamination monitor. If the levels are 3x or greater than background, then the emergency stop button will be activated, the equipment powered down and room closed and locked. A specialist engineer will then be called out.

TABLE 1

Step	Who is Affected	Hazard		Initial Risk			Controls	Residual Risk		
		Description	Effect	SF	FF	R	List of Controls Required	SF	FF	R
1	X-Ray Operator	External Radiation Dose due to exposure to hands to by placing in main beam.	Localised radiation burn	3	3	9	Strict adherence to Local Rules required. All shielding interlocked doors tested on a regular basis. Interlocks must **not** be bypassed	2	1	2
2	X-ray Operator	Radiation dose external to the shielded cabinet	Possible risks of cancer	3	1	3	All interlock shielding doors to be regularly tested. Strict adherence to the Local Rules and Guidance. Equipment taken out of service if dose/counts are 3x greater than background	1	1	1
3	X-ray Operator	Failure of the shutter to stop the X-ray beam when the interlocked door is opened.	Possibility of raising risk of some form of cancer.	3	2	6	Strict adherence to the local rules. Regular checks on the interlocked doors. Checks that all appropriate lights change when the shutter is closed. Regular maintenance of equipment. If radiation detected 3x above background when interlocked doors opened, then equipment taken out of service and specialist engineers come to fix.	1	1	2
4	X-ray Operator	A lack of understanding of the equipment.	Interlocked shielding must prevent anybody opening the equipment while there is an active X ray beam	2	2	4	Only trained and authorised users will have access to equipment. Only approved users who have had appropriate training will be registered as Users.	1	1	1

5	X-Ray Operator	Exposed to scatter X-rays due to shielding being ineffective or damaged	Possibility of raising risk of some form of cancer.	2	2	4	Effectiveness of shielding confirmed every month. If there is 3x background radiation leakage from the equipment, the equipment is taken out of service and repaired by a specialist engineer.	1	1	1
3	Administrative Staff	No administrative staff can be present in the laboratory when X-ray equipment is in use	Possibility of raising risk of some form of cancer.	1	1	1	Signage on the door that X-rays in use and no authorised personnel have access  	1	1	1
4	Cleaners	Cleaners will not have access to areas of use without authorisation	Possibility of raising risk of some form of cancer.	1	1	1	Signage on the door that X-rays in use and no authorised personnel have access.   No cleaners will be allowed in the room unless the equipment is powered down and the keys removed from the equipment to ensure that NO X-rays can be generated.	1	1	1

Matrix of Risk Level					
Severity Factor (SF)					
Frequency Factor (FF)		Slightly Harmful (1)	Harmful (2)	Very Harmful (3)	Extremely Harmful (4)
	Very Unlikely (1)	1	2	3	4
	Unlikely (2)	2	4	6	8
	Possible (3)	3	6	9	12
	Probable (4)	4	8	12	16

Risk (R) = Frequency factor (FF) x Severity of Harm (SF)		
Risk Rating (R)	Classification	Action Required
1-2	Low	No additional controls
3-4	Acceptable	Consider additional controls
6-9	Moderate	Additional controls to be made
12-16	High	Task must not be completed. Look for alternative method

ACoP Paragraph 71 – Outcomes of the assessment

71(a) - Actions taken to keep exposures ALARP

Samples will only be loaded when the X-ray beam shutter is activated or the equipment is not powered. This is stated within the Safe System of Work for loading samples (see Appendix 2).

All work with X-rays will be behind interlocked shielding. There will be no open x-ray beams.

All shielding and interlock systems will be regularly tested with a dose rate meter or a scintillation probe contamination monitor. If readings are greater than 3x Background, then the emergency stop button will be activated, the equipment depowered, the key for the power supply removed and room locked. A specialist engineer will be called for to repair the equipment before it can be reused.

71(b) - What Engineering Controls, Warning Signals and other Safety Systems are necessary

When equipment is not in use, the key to the power supply will be removed so that the equipment cannot be accidently started up

All doors to the X-ray equipment have interlocked shielding doors to stop the beam when the door opens.

Equipment will have illuminated signage on the equipment to show when X-ray beams are being generated. Where these lights fail, the equipment will be taken out of service immediately and repaired by a specialist engineer.

Door to the laboratory will have warning signs about the use of X-rays and that only authorised personnel may enter.

71(c) - Whether PPE is appropriate and if so what type

None appropriate - Only general laboratory personal protective equipment eg Laboratory coat, eye protection and if necessary, disposable nitrile gloves.

71(d) - Dose Constraints
An investigation action level of 0.5 mSv/2months has been adopted.
71(e) - Protection of female employees
No special protection required. All X-ray beams are within interlocked shielding and thus there should be no dose to those in the room. Regular checks of the interlocks and shielding will be undertaken and if radiation levels are 3x or above background then the equipment should be shut down and a specialist engineer called to repair the equipment. All female staff will be notified if the shielding and/or the interlocks have failed. All expectant mothers will have a specialised risk assessment undertaken for this work once management have been notified of the status of the expectant mother.
71(f) - Investigation levels
An investigation action level of 0.5 mSv/2months has been adopted.
71(g) - Maintenance and testing schedules
Annual maintenance contract held with manufacturer. Regular internal inspections of equipment. Equipment transferred to engineer when working on it. Monthly checks on the interlocks and radiation leakage through the shielding will be undertaken by University staff and recorded in writing. Emergency Off buttons will be tested by a Specialist engineer on an annual basis. A record of all users of the equipment will be kept.

71(h) - Contingency Plans

As identified in Local Rules.

71(i) - Training needs

All users must be trained and undergo the University Radiation Protection Course and the ARPS X-ray awareness training courses from 2021.

All relevant staff eg cleaners will be instructed in the meaning of specific signage

71(j) - Designation of Controlled and Supervised Areas

The inside of the equipment will be deemed a 'Controlled Area' while the X-ray beam is on. Equipment will be suitably signed:

The laboratory area will not be deemed a 'IRR Designated Area' on the basis of regular monitoring of equipment shows no dose rates, that whole body radiation dosimeter badges show no dose. The door to the laboratory with the equipment will have a sign on the door stating:

71(k) - Access restrictions and other precautions for designated areas

Laboratories with this equipment in are restricted to authorised personnel only

71(l) - Designation of persons

Not required. No work on open X-ray beam thus the risk to workers will be below 2.5μSv/hr

71(m) - Personal dosimetry

Whole body radiation dosimeters are only issued to the main users of the equipment

71(n) - Leak testing of radioactive sources
N/A
71(o) - Responsibilities of managers
Ensure that Local Rules are followed, that the contents of this risk assessment are complied with and ensure that all staff are properly trained.
71(p) – Monitoring / auditing program to ensure compliance with IRR77
RPA to audit operations every two years and the URPO to do an annual isnepction.

Assessor (sign):

Dr Paul Szawlowski, University Radiation Protection Officer and Deputy Director of Environmental, Health and Safety Services (12/07/2021)

Appendix 1

RADIATION CONTROLLED AREA AND EQUIPMENT HANDOVER FORM

Part 1: School/unit – Handover of Controlled Area and Equipment to Company Representative			
SITE:		CONTROLLED AREA / ROOM:	
COMPANY CARRYING OUT WORK:			
REASON FOR HANDOVER:			
IDENTIFY KNOWN HAZARDS WITH CONTROLLED ARE OR EQUIPMENT:			
As an authorised representative of the School/Unit I hereby hand over the controlled area and equipment as above. Information has been exchanged to enable appropriate risk assessment to be made.		Company: As an authorised, and suitably trained, representative of the company, I accept responsibility for the controlled area and equipment. I will work in compliance with my employer's procedures and Local Rules.	
School/Unit Representative:	Signature:	Company Representative:	Signature:
Date:	Time:	Date:	Time:

Part 2: COMPANY REPRESENTATIVE – Handover of Controlled Area and Equipment to School/Unit Please tick all applicable categories of work carried out. See visit / service report for full details.	
Category of Work	Details
☐ Routine Service	
☐ Fault Diagnosis / Repair	
☐ Installation of Part(s)	
☐ Upgrade / Modification	☐ Hardware / ☐ Software
☐ Incident Response	
☐ RPA Inspection	
☐ Exposure Protocol Changes	
☐ Other	

Could this work have implications for radiation safety of image quality?	☐ NO / ☐ YES

If "Yes", tick one or more boxes below that apply. Please refer to the visit / service report for full details.

☐ Shielding	☐ Interlocks / Exposure termination	☐ Safety features / warning devices
☐ Beam quality / filtration / grid	☐ Collimation / alignment / field sizes	☐ Detector dose / input dose

☐ 1. Equipment is OPERATIONAL following work as indicated above and detailed on the visit / service report.

☐ 2. Equipment is PARTIALLY OPERATIONAL, but limitations may exist, please refer to visit / service report.

☐ 3. Equipment is NOT OPERATIONAL and MUST NOT BE USED.

Part 3: School/Unit – Returning Equipment to Use I confirm that I have been authorised as a competent practice representative ☐
I confirm that the above Company has provided information and that I have reviewed the associated service report (if applicable) and appropriate checks have been carried out in accordance with my employer's procedures ☐
☐ 1. I am satisfied that the equipment is in a satisfactory condition for use.

☐ 2. I am NOT satisfied that the equipment is satisfactory for use. Reason: Actions taken:			
School/Unit Representative:	Signature:	Company Representative:	Signature:
Date:	Time:	Date:	Time:

Appendix 2

System of Work to load samples into a XRD or XRF machine - To eliminate or minimise the risk of exposure to X-rays.

Version number	Purpose / changes	Document status	Author of changes, role and school / unit	Date
v1.0	New Document	Approved	Dr Paul Szawlowski	12/07//2021
v1.1	Typographical changes	Approved	Dr Paul Szawlowski	16/07/2021