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RADIATION PROTECTION SERVICE

DEPARTMENT OF WELLBEING, SAFETY AND HEALTH

UNIVERSITY OF LEEDS

RADIATION RISK ASSESSMENT 05:
CABINET X-RAY DIFFRACTION SYSTEMS

1. SCOPE AND PURPOSE

This radiation risk assessment is for the use of fully enclosed cabinet x-ray diffraction (XRD) systems.

The purpose of this risk assessment is to assess the risks from exposure to ionising radiation in order to identify the measures needed to restrict the radiation exposure of employees or other persons and it has been prepared in accordance with the guidance given in ACoP 8 to the Ionising Radiations Regulations 2017 (IRR17).

2. DOCUMENT CONTROL

Version	Author	Date of issue/review	Comments
1.3	IKH	7 October 2014	
1.4	ARC	9 October 2017	Review and minor updates
2.0	ARC	9 February 2018	Major update for IRR17
2.1	ARC	7 September 2018	Minor revisions

3. NATURE OF SOURCES OF IONISING RADIATION

XRD systems covered by this risk assessment include stand-alone and desktop systems contained in cabinets or enclosures.
Typical operating parameters for generating x-rays are 30-50kV and 10-50mA.
Each system is housed in a shielded and interlocked enclosure that is either a fully integrated part of the original equipment or is an in-house designed interlocked enclosure that fully encloses the system (x-ray head, sample stage and detectors).
Details for each system can be found on the RPS x-ray database.

4. DOSE ASSESSMENTS

Enclosure manufacturer's specifications are that accessible dose rates are less than 1µSv/h.
Commissioning tests by the installer and leakage radiation measurements undertaken by the UoL Radiation Protection Manager (see CE report for each system) show that in all cases radiation dose rates are less than 0.5µSv/h at any point on the external surface of the enclosure and doses at an operator position are negligible.
Additionally one in-house enclosure (XRID24) incorporates a hand access port where accessible dose rates up to 1µSv/h to the hand can be reached within the enclosure [a].
From x-ray tube emission data estimated radiation dose rates close to the unshielded tube will be of the order of up to 30 Gy/h [b], and scatter dose rates up to a few mGy/h [c].
Estimated doses should be compared with:

- University of Leeds dose constraint for radiation workers = 1mSv/year [d]
- Dose constraint for exposures to the public from any new source of radiation = 0.3mSv/year [e]
- Average radiation dose to the public in the UK = 2.7mSv/year [f]

EXTERNAL DOSES

Estimated radiation dose rates to which anyone can be exposed:

- Radiation dose rates at the operator position during normal operation of the x-ray unit and enclosure are negligible.
- Accessible dose rates of <0.5µSv/h close to the enclosure would result in <1mSv dose if the operator remains in this position with the system operating for a whole working year. Therefore estimated body doses are <<1mSv (University dose constraint).
- Radiation dose rates if there is a failure or malfunction of shielding or interlocks could be up to $30Svh^{-1}$ in the primary beam and scatter dose rates of up to a few $mSvh^{-1}$.

INTERNAL DOSES

Likelihood of contamination arising and being spread

Not applicable – x-ray source.

Estimated levels of airborne and surface contamination

Not applicable – x-ray source.

5. DOSIMETRY

The use of dosimetry is not appropriate for these activities as radiation levels would not be detected by dose meters.

6. SAFE USE AND MAINTENANCE

Manufacturer's guidance on safe use and maintenance are followed and incorporated in the operating instructions.

Where appropriate the equipment is subject to a maintenance / service contract.

Safety features such as interlocks, warning lamps, and emergency stops are checked and tested regularly.

7. ENGINEERING CONTROL MEASURES AND DESIGN FEATURES

X-ray enclosures are compliant with ACoP 9(2) of IRR17.

Engineering controls and safety features include adequate shielding and interlocked door access.

Warning lamps are fitted to each enclosure to indicate x-ray emission.

8. PLANNED SYSTEMS OF WORK

Local rules are in place and specify:

- Requirements for management of work, training and authorisation.
- Requirements for critical examinations.
- Requirements for monitoring of dose rates.
- Work instructions including instructions for controlling exposures.
- Contingency plans.

Operating instructions for the equipment are kept in each lab.

9. PERSONAL PROTECTIVE EQUIPMENT

No additional PPE is required for this work.

10. ACCESS TO AREAS WHERE THERE ARE SIGNIFICANT DOSE RATES OR CONTAMINATION LEVELS

Each laboratory is secured with access control systems (e.g. a programmable key-fob) and only authorised personnel have access.

Each lab is classified as an Undesignated Area as x-ray exposure levels during normal operation are negligible.

11. RISK EVALUATION AND CONTROLS

	Risk evaluation	Control measures	Residual risk after controls		
			Likelihood	Severity	Risk
Radiation exposure during normal use	X-ray leakage and scatter dose rate <0.5µSvh^{-1} at all points and much less than this at operator position. Risk during normal use is negligible (very much less than the university's dose constraint of 1mSv/y).	Operator training. Local rules include working instructions and emergency procedures. Regular dose rate monitoring around the enclosure and interlock check. Critical Examination before the x-ray tube is first used; if repaired, altered or moved. Regular maintenance and servicing of the equipment. Annual critical examination and audit by Radiation Protection Manager.	**Low**	**Low**	**Low**

Possible accident situations or failure of control measures and steps to prevent or limit their consequences	**Removal of panels / shielding giving access to unguarded x-ray beam** Removal of panels or shielding could give access to areas where there is a high dose rate. Radiation exposure could exceed the University annual dose constraint of 1mSv. Dose rate could exceed dose constraint and legal dose limits.	Operator training. All repairs and modifications to the equipment must only be carried out by a qualified service engineer. The service engineer must have sole use of the room if servicing requires the removal of shielding or over-riding of safety features.	**Low**	**Medium**	**Low**
	Damage to the equipment by misuse, impact or fire X-rays; potential dose rate – Svh^{-1}. Scatter dose rate - $mSvh^{-1}$. If the equipment were subject to damage the x-ray shielding may be compromised and radiation exposure could exceed dose constraints and legal dose limits.	If the equipment, enclosure or interlocks have been damaged in any way or a malfunction is suspected the user should: - switch the power off and remove the keys - inform the RPS who will arrange for the equipment to be checked by an engineer.	**Low**	**Medium**	**Low**
	Interlocks not functioning and panels open X-rays; potential dose rate – Svh^{-1}. Scatter dose rate - $mSvh^{-1}$. If the interlocks failed the equipment should fail to safe and not be operable. However if the equipment was still operable radiation exposure could quickly exceed dose constraints and legal dose limits.	Regular dose rate monitoring around the enclosure and interlock check. Critical Examination before the x-ray tube is first used; if repaired, altered or moved. Regular maintenance and servicing of the equipment.	**Low**	**Medium**	**Low**

12. REFERENCES

[a] UoL Critical Examination report CRIT1825 XRID24 PHYSICS.

[b] Handbook of Radiological Protection, Part 1: Data, HMSO 1971.

[c] Radiation Shielding for Diagnostic X-rays, BIR/IPEM 2000.

[d] Management of Sources of Ionising Radiation - Guidance, Health and Safety Services, November 2016.

[e] Work with ionising radiation, Ionising Radiation Regulations 2017, Approved Code of Practice and Guidance, HSE, 2018.

[f] Ionising Radiation Exposure of the UK Population: 2010 Review, PHE-CRCE-026, Public Health England, April 2016.