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RADIATION PROTECTION SERVICE

DEPARTMENT OF WELLBEING, SAFETY AND HEALTH

UNIVERSITY OF LEEDS

RADIATION RISK ASSESSMENT 25:
RIGAKU ZSX PRIMUS II X-RAY FLUORESENCE SPECTROMETER

1. SCOPE AND PURPOSE

This radiation risk assessment is for the use of a Rigaku ZSX Primus II X-ray Fluoresence Spectrometer.

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
1.0	ARC	30 September 2015	
2.0	ARC	7 September 2018	Major update for IRR17

3. NATURE OF SOURCES OF IONISING RADIATION

The Rigaku ZSX Primus II is an x-ray fluorescence spectrometer used for rapid quantitative determination of major and minor atomic elements, from beryllium (Be) through uranium (U), in a wide variety of sample types.
Typical operating parameters for generating x-rays are 60kV and 66mA.
The x-ray system is housed within an interlocked enclosed cabinet with the x-ray generator sitting inside a purpose built shielded housing. The system consists of a steel enclosure with sample drawer, door and viewing panel. Sample holders are placed on drawer and a robotic arm takes them into the sample chamber for analysis. The door and drawer can be open whilst x-rays are on and interlocks control the robotic mechanism.
System details can be found on the RPS x-ray database (XRID42).

4. DOSE ASSESSMENTS

Commissioning tests by the installer and leakage radiation measurements undertaken by the UoL Radiation Protection Manager (see CE reports) show that 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.
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 [a], and scatter dose rates up to a few mGy/h [b].
Estimated doses should be compared with:

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

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

The equipment is subject to a lifetime maintenance / service contract.

7. ENGINEERING CONTROL MEASURES AND DESIGN FEATURES

X-ray enclosure is compliant with ACoP 9(2) of IRR17.

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

Warning lamps 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

The laboratory is secured with a programmable key-fob system and only authorised personnel have access.

The 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. Critical Examination before the x-ray system 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. 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] Handbook of Radiological Protection, Part 1: Data, HMSO 1971.

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

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

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

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