UNIVERSITY OF EDINBURGH
GENERIC RISK ASSESSMENT - RADIATION

RP/RA8 - WORK WITH X-RAY FLUORESCENCE ANALYSERS

Foreword

This is a generic risk assessment for use by persons involved in or effected by the application of radiation outlined in the Scope section below. It must be read together with the relevant completed and countersigned Proposed Scheme of Work form. Together they make up the radiation risk assessment of each application for each person working with radiation in the University. The specific control measures for each application are recorded in the relevant Local Rules.

Where risks are recognised with an application that are not included in this assessment the University Radiation Protection Adviser must be informed.

[Note that this risk assessment refers only to the radiation risks arising from work with X-Ray Fluorescence (XRF) Analysers. There are other more general risks arising from work with XRF Analysers and these must be properly assessed using the University's general risk assessment approach. Guidance can be obtained from the Health and Safety Department.]

- *Fully enclosed XRF*

- *Not enclosed but not handheld*

- *Typical handheld XRF*

Scope

This risk assessment applies to routine operations regarding the University's work with portable XRF Analysers used for material or elemental analysis. Typical types of portable XRF analysers are shown above and can roughly be categorised into 3 types: fully enclosed, not enclosed but not hand-held, and not enclosed but held in the hand during operation.

Hazards

- Irradiation of part or whole of the body to external x radiation during normal use.
- Irradiation of part or whole of the body to external x radiation in case of an accident;

Persons likely to be exposed to the hazard: University staff, research staff, students, visiting workers, other workers (e.g. interns) and members of the public. Pregnant women and persons less than 18 years old would be at particular risk.

Risk before the implementation of control measures:

Category of Person	High	Medium	Low
University staff, research staff, students, visiting workers and other workers (e.g. interns)		✓	
Members of the public			✓
Persons particularly at risk: • Pregnant women and young persons		✓	

The radiation levels in the main beam of an XRF analyser can be very high and can exceed 1Sv/h at the aperture and can still exceed 1mSv/h at 50cm.

Scattered radiation levels are very much dependant on the sample being analysed and the type of XRF equipment used. Typically, scattered radiation levels are very low for fully enclosed XRF equipment or for equipment where the x-ray beam is focussed onto a small area of the sample (e.g. around 1 mm^2).

Scattered radiation levels from hand-held XRF devices can typically be up to 500 μSv/h at 10cm around the front of the instrument near the aperture/sample but are generally less than 1 μSv/h at the trigger and at other areas around the unit away from the aperture.

Reasonably foreseeable accidents:

Type of Incident	Possible Effects
X-rays don't switch off when asked to do so.	Exposure to the main beam resulting in an unnecessary radiation exposure above a dose limit.
Equipment begins generating x-rays when it has not been asked to.	Exposure to the main beam resulting in an unnecessary radiation exposure above a dose limit.
A failure (i.e. mechanical, electrical or accidental damage) resulting in a person or persons being exposed to the x-ray beam	Exposure to the main beam resulting in an unnecessary radiation exposure above a dose limit.

Type of Incident	Possible Effects
Procedural failure resulting in an unintended exposure	Exposure to the main beam resulting in an unnecessary radiation exposure above a dose limit.
Accident leading to an overexposure	Skin reddening unlikely to occur unless exposure in excess of 1hr; Exposure to the main beam resulting in an unnecessary radiation exposure potential restriction of work duties following the overexposure
Unauthorised use of the equipment	Exposure to the main beam or scattered radiation resulting in an unnecessary radiation exposure above a dose limit.
Theft / loss of the equipment	Exposure to the main beam or scattered radiation resulting in an unnecessary radiation exposure above a dose limit.

Justification and Optimisation

It is assumed that the analysis of materials by XRF is needed to fulfil the desired work. The use of radiation generators for detection and analysis is an existing justified practice[1].

Control Measures

At the design or procurement stage for a project utilising an XRF analyser, consideration should first be given to whether the x-ray hazard can be engineered out; for example, by carrying out the work using a fully-enclosed piece of equipment or in an interlocked enclosure. It is always better to minimise the risk of exposure to x radiation using engineering controls than to minimise the risk using procedural and behavioural controls.

Technical

- All XRF analysers, must:
  - Have a clear warning label on them to indicate that they are capable of emitting ionising radiation. This should be in a prominent position on the front of the instrument.
  - Have some form of key-operation or password protection to prevent unauthorised use of the equipment.
  - Have sufficient shielding to ensure leakage dose rates are not greater than 3 μSv/h around the equipment (except at the aperture);
  - Have a warning light to indicate when x-rays are being generated;

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/717288/180618_JustificationGuidanceDoc_updatedannex.pdf

- Have a maintenance contract in place, or if this is not required for warranty purposes, at least access to the manufacturer who can check that the equipment is performing as expected.
- Only be repaired/maintained by properly trained and authorised persons (i.e. by the manufacturer or an agent of the manufacturer).
- Be taken out of service if they are thought to be damaged or if any of the safety features are not working.

- XRF analysers that are 'fully-enclosed' must also have:
  - Adequate shielding such that the radiation dose rate at any point on contact with the surface of the equipment does not exceed 3 μSv/h.
  - Any access points (e.g. door(s), hatch(es), panel(s)) either interlocked or fixed/bolted down to prevent access to the main x-ray beam. Opening of any of these access points must close the shutter on the x-ray tube or de-energise the x-ray generator.

- XRF analysers where access to the main beam is permitted under normal conditions of use must also:
  - If hand-held, have a two-handed option which ensures the user has both hands on the equipment during measurements;
  - If hand-held, have an exposure control trigger on the instrument that if released, stops the x-rays being generated;
  - Ideally have both of the safety features outlined below, but where this is not practicable, at least one of them must be fitted:
    - A proximity sensor which is enabled under normal conditions of use to prevent x-rays being generated when there is not a sample held against the aperture;
    - A low-count backscatter detector to turn off the x-rays if at any point in the measurement it detects a low count (e.g. if the sample has been moved away from the aperture/sample area);
  - Not permit reinstatement of the x-ray emission if the x-ray emission is interrupted at any point during the measurement (e.g. if the sample is moved away from the aperture and the x-rays stop, the mere act of moving the sample back in front of the aperture must not re-start the measurement). A manual intervention must be made to restart x-ray emission.

Procedural

- The procedures for safe operation of XRF analysers must be written down in Local Rules.
- Where access to the primary x-ray beam is possible under normal conditions of use, a Controlled Area must be set up whenever the equipment is in a ready-state such that it is capable of producing x-rays.

- Where access to the primary x-ray beam is possible under normal conditions of use, a suitable real-time radiation monitor must be used to detect enhanced levels of radiation in the area. This can be achieved by either placing a hand-held radiation monitor such as the Mini Instruments 900 type 'E' in the Controlled Area near the sample or by the operator wearing a suitable Electronic Personal Dosimeter (EPD).
- Where practicable, operate the XRF analyser from outside the designated Controlled Area.
- Only essential personnel must remain in the Controlled Area during measurements.
- If a person's presence in the Controlled Area is essential, they should position themselves as far away from the x-ray equipment or sample as practicable (note, the operator may need to be close to the equipment if they are operating a hand-held XRF analyser).
- The shortest measurement time to achieve the desired result must be used.
- Where practicable, e.g. for small samples, carry out measurements in a shielded enclosure which is interlocked to prevent access to the main x-ray beam.
- Operation of XRF equipment must only be by persons trained in the correct use of the equipment.
- The equipment must be kept secure when not in use.
- The operator must wear a whole-body radiation dosemeter or extremity dosimeter during measurements if this advised in the Local Rules or PSoW form.
- Visual inspection of the equipment for damage must be carried out by the operator before use.
- If the XRF equipment is to be left unattended for any length of time or when it is not being used, it must be made safe. For example, by disconnecting the battery pack, by disconnecting cables that permit x-ray generation or by activating password protection on the equipment or enabling software.
- Plans must be drawn up and included in the Local Rules for procedures in case of the accidents listed above.

Behavioural

- Persons operating fully-enclosed XRF equipment, where there is NO practical access to the main x-ray beam, do not require specific radiation safety training and can achieve adequate information and instruction by:
    - Reading the relevant University Radiation Protection Unit Guidance Note on enclosed x-ray apparatus;
    - Completing the relevant PSoW for enclosed x-ray apparatus; and,
    - Receiving local instruction on the general use of the equipment
- Persons operating XRF equipment where there IS access to the main beam under normal conditions of use must be authorised using the University's radiation authorisation arrangements, which includes the radiation protection training arrangements.

- A Radiation Protection Supervisor must be appointed to provide suitable supervision of the use of XRF equipment *where there is access to the main x-ray beam under normal conditions of use*.
- For XRF equipment in which there is no access to the main x-ray beam under normal conditions of use (i.e. for fully-enclosed XRF equipment), the following is advised:
    - If an RPS is appointed for the area, appoint the RPS to carry out local equipment training and to countersign PSoW forms.
    - If no RPS is appointed for the area, the default position is that the Line Manager takes responsibility for local equipment training and to countersign PSoW forms.
- The appointed RPS must be trained in the measures required to ensure compliance with the controls outlined in this risk assessment and with the Local Rules.
- For XRF analysers that are not fully enclosed, the main x-ray beam must never deliberately be pointed at any part of the body.
- Samples must never be held in the hand during measurements.

Dose Constraint

No special dose constraint is required for work with XRF analysers.

Dose Investigation Level

In view of the fact that the majority of the risks can be controlled by technical means and scattered radiation levels are generally low, classified workers should not be required for work with XRF analysers.

The need for personal dosimetry for XRF analysers depends on the type of analyser (e.g. fully enclosed or not) and is discussed in the relevant Local Rules for the XRF equipment. The need for personal dosimetry is then communicated to the users by return of their Proposed Scheme of Work form.

Dose investigation levels are set out in the relevant Local Rules for the XRF equipment but will not exceed a cumulative dose of 6mSv over the year.

Risk after the implementation of control measures:

Category of Person	High	Medium	Low
University staff, research staff, students, visiting workers and other workers (e.g. interns)			✓
Members of the public			✓
Persons particularly at risk: pregnant women and young persons			✓