Radiation Safety Guidelines for Use of X-ray Diffraction Instruments

X-ray Diffraction Laboratory
Mark Wainwright Analytical Centre
UNSW Sydney

Version 2.1

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1. Radiation Safety Legislation and Code of Practice

1.1 Radiation Safety Legislation, Code of Practice and Rules

Besides the general occupational health and safety (OHS) practice, working with sealed/unsealed radiation sources in NSW is regulated under the *NSW Radiation Control Regulation 2013*, *Australian/New Zealand standard (AS/NZS 2243.4:2018)* and *Code of Practice for the Security of Radioactive Sources (2019)*. We have a statutory obligation to comply with the requirements and practices described in these documents. The documents can be accessed through UNSW Library's online services.

UNSW Sydney has developed its radiation policy - "OHS 601-Ionising Radiation Procedure". It is accessible from the UNSW web site (https://research.unsw.edu.au/document/ionising-radiation-procedure). The policy clearly outlines the all practical requirements and responsibilities of those, who are working with radiation sources or supervising the use of radiation sources in UNSW. All XRD users must read this policy before starting their XRD work.

The X-ray diffraction laboratory in the Analytical Centre UNSW has fully complied with all of the above legislation, codes and policies. All users/operators have the responsibility to follow these continuously.

1.2 Radiation Licensing and Training

All intending users of ionising radiation sources must first obtain a radiation licence from the Environment Protection Authority (EPA) (https://www.epa.nsw.gov.au/). This applies to most users. The licence will indicate the type of radiation sources to be permitted, where appropriate and conditions.

An exception to this rule is all users working with sealed radiation sources at a fixed location. In this case, a Licensing Exemption Approval has to be provided in writing, identifying the student, the supervisor and the details of the work to be taken and any conditions associated with it. Using X-ray diffraction units, at X-ray diffraction laboratory, Analytical Centre UNSW is licensing exempted.

All users (licensed and licensing exempted) must undertake a training program for radiation safety and instrument operation before they can use X-ray diffraction units in the XRD laboratory. Only qualified and licensed staff can provide this type of training. The training program must have an appropriate record of trainer/trainee, date and associated. The trainee should obtain a copy of radiation guidelines and standard operating procedure for the specified XRD instrument.

1.3 Radiation Supervision

In the XRD laboratory, only qualified staff can provide radiation supervision. Their names have been displayed on the radiation safety information board in the lab.

The responsibilities of the Radiation Safety Supervisor include.

- Obtain and maintain knowledge of the principles and practices of protection against radiation and of potential hazards;
- Training users for radiation safety and standard operation;
- Approving standard operating procedures;
- Approving student exception to access XRD units, and
- Identifying local radiation risk areas.

For X-ray radiation safety issues, please contact

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1.4 Risk Assessment

Before starting an XRD experiment, a risk assessment must be carried out. The user should fill out the Risk Assessment form and submit to the radiation safety supervisor at the XRD laboratory.

1.5 Radiation Safety Information Board in XRD Laboratory

The Radiation Safety Information Board in the XRD Laboratory provides all information about radiation safety, which includes licenced staff names, student names under radiation licensing exemption, radiation footprint, emergency evacuation procedure, incident reporting procedure and radiation legislation documents.

2. Working with X-ray Diffraction Instruments

2.1 Characteristics of X-ray Radiation

X-rays are a very energetic form of electromagnetic radiation that will ionise matter with which they interact, by ejecting electrons from their atoms. They are classified as sealed radiation sources, when devices or materials, which generate X-rays, have been permanently bonded or fixed in a capsule or tube to prevent release and dispersal of radiation under the most severe conditions and unsealed radiation sources such as radioactive substances. The X-rays used in X-ray diffraction (XRD) unit is the sealed radiation sources which are enclosed in X-ray tube housing and produced only when they are energized.

X-ray radiation is harmful to the human body. A localised dose is sufficient to cause a severe radiation burn (human tissues are killed). Doses are also accumulated in the human body by long-term exposure to radiation that produces irradiated cells. The hazards include an increased risk of leukaemia, cancer and genetic or hereditary effects.

Injury may occur to the operator and/or other personnel close to X-ray equipment due to exposure to a primary beam or leakage or scattered radiation.

X-ray's wavelength, used with XRD, is around 0.5 – 2 Å. They are invisible to the naked eye and strongly penetrative. However, they are generated by electric power. Once the electric power is cut off, X- rays will completely vanish and no radioactive contamination remains in the area, no radiation hazard exists.

Three major factors are considered in preventing radiation hazard – time, distance and shielding.

2.2 Radiation monitoring and Permitted dose

The IS measurement of X-ray intensity is the Sievert (Sv), corresponding to the absorption of one joule in one kilogram of biological matter, taking into account the quality factor and other modifying factors.

The radiation monitor measures the radiation in terms of rate - μSv/hr (micro-Sievert per hour). The normal background radiation level in our XRD lab is on the order of 0.2 –0.5 μSv/hr. At this rate, one would expect to receive maximum 0.5x 24 hr = 12 μSv of exposure per day or 0.5x24x365 = 4.38 mSv/year.

Standard limits of effective dose are 20 mSv/year for occupationally exposed persons and 1 mSv/year for the general public. Doses received from natural background radiation (1.5 mSv/year) and medical exposures do not count towards occupational exposure. Typically, the maximum received doses for the general users working in the XRD laboratory should be less than 2.5 mSv/year.

A radiation monitor is provided in the XRD laboratory. All users need to know how to use the monitor. The results from lab inspections show on the Radiation Safety Information Board.

2.3 Radiation Protection Features in XRD Instrument

All X-ray diffraction instruments have equipped with many radiation-protective features. Understanding of these features is the most important step to ensure radiation safety.

- **X-ray tube housing** Each X-ray tube is enclosed in a tube housing that cannot be fractured or deformed by normal use, accidental impact or misuse.
- **The tube housing shutter** (X-ray beam stop) is placed close to the housing aperture so that to attenuate the radiation doses. The shutter is opened only when measurement starts.
- **X-ray energised warning indicator (light)** indicates X-ray tube is in operation and X-ray are generated, but they could be enclosed in the tube housing only.
- **Shutter warning indicator** If it is on, it indicates the shutter is opened. X-rays are in the working chamber. In this case, no one is allowed to open the door of the chamber.
- **Interlocks** Many microswitches are fit on each XRD system to ensure that the sample chamber has been properly enclosed before the shutter opens. Any attempt to open the chamber, when the shutter is opened, will lead to system de-energised immediately.
- **Sample chamber** It houses the test samples and prevents accessing the primary X-ray beams. The chamber is constructed of appropriate materials to attenuate X-ray radiation during measurement.

2.4 Understanding Lab safety Features and Requirements

- **Push-off button (Red Push Button)** each XRD unit has a push-off button to shut down electric power. They are all labelled with red “Power Off” whatever its location and type. Users should know its location and push it in an emergency case.

  It can only be used in case of emergency.

- **Service/disruption Notice (Yellow Note)** A yellow note is stored in the operating procedure folder of each unit. When the user finds a problem of operation or safety, please shut down the unit, put the note in front of the unit and then inform the lab safety supervisor.

When the user finds a yellow note has been placed to an XRD unit, don't use that unit until a school technical staff takes it off.

Users are not allowed to do any repair, adjustment or modification of XRD hardware. Anyone, who tries to do so, will be dismissed from use XRDs in the laboratory.

- **Safe Samples** To maintain a safe environment of the lab, the safety supervisor may ask users to provide certain information on their samples. Users should ensure that their samples will not contaminate the lab.

  User must report to safety supervisor if their samples may contain radioactive substances, nano-powders, something which may produce toxic gases under the low heat, or lead to contaminate instrument. Without taking necessary precautions, the user cannot perform any test to those samples.

  The lab cannot be used as a sample preparation room and not store any type of samples.

2.5 Medical Requirements

The operator or any other person involved in the use of XRD equipment should undergo a medical examination following any known or suspected occasion when the person has been exposed to a primary beam from XRD equipment.

Radiation Safety Rules for Use of XRD Instruments

1.1 Check the placard on the door to know main potential hazards, the personal protective equipment to be worn and the names and phone numbers of the persons to be contacted for emergencies.

1.2 No person is permitted to operate XRD equipment unless they have taken training of radiation safety and operating procedures and done the risk assessment. All users must follow the standard operating procedure to use XRD unit.

1.3 Check "Service/Disruption Notice" (Yellow note). If one has been placed to an XRD instrument, don't use that instrument until technical staff takes it out.

1.4 Check shutter indicator before opening the door of the sample chamber. If the indicator lights on, don't open the door of the chamber at any circumstance.

Shutter lights on indicate that there is X-ray in the chamber.

1.5 Turn off the equipment immediately when potentially hazardous situations occur arising from X-ray beam, due to any reason. Report to the radiation safety supervisor any actual or suspected case of radiation exposure.

In the case of a building emergency, switch off the equipment completely before leaving the laboratory.

1.6 In the case of the radiation exposure incident, you must follow "Hazard and Incident Reporting and Investigation Procedure" on the radiation safety information board or https://research.unsw.edu.au/recs/radiation-safety.

1.7 Recording your usage time, with actual operator's name (not research group), in the specific XRD logbook after use.