

Radiation Safety Committee

College of William and Mary

Policy for the operation of Analytical X-ray Equipment

The following rules govern the use of analytical X-ray equipment at the College of William and Mary. These rules comply with the radiation safety standards recommended by the Commonwealth of Virginia and the American National Standards Institute (ANSI).

Open and Enclosed-Beam Analytical Systems

The following are requirements for both open-beam and enclosed-beam analytical X-ray systems.

1. Warning Lights

An easily visible warning light labeled "X-RAY-ON" shall be located near any switch that energizes an X-ray tube. It is to be illuminated only when the tube is energized. This light shall be of a fail-safe design.

2. Labeling

All analytical X-ray equipment shall be labeled with a conspicuous sign or signs that bear the radiation symbol and the words (or similar words):

1. "CAUTION - HIGH-INTENSITY X-RAY BEAM" on the X-ray source housing.
2. "CAUTION - RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" near any switch that energizes an X-ray tube.

3. Beam trap

A beam trap or other primary beam shield shall be provided to intercept the primary beam.

Additional Requirements for Enclosed-Beam Systems

1. Chamber

The X-ray tube housing, sample detector, and analyzing crystal shall be enclosed in a chamber (or coupled chambers) that prevents entry of any part of the body.

2. Ports

Access ports to the sample chamber shall be of a fail-safe design that prevents X-ray generation or entry of the X-ray beam into the chamber when any port is opened.

Additional Requirements for Open-Beam Systems

1. Safety device

An interlocked safety device, which prevents entry of any part of the body into the primary beam or causes the beam to shut off, shall be provided on all open-beam systems.

An authorized user may seek an exemption from this requirement by applying to the Radiation Safety Officer. The application shall include:

1. A description of the safety devices evaluated and why they cannot be used.
2. A description of the alternative method that will be used to minimize the possibility of an accidental overexposure.
3. Procedures that will be used to alert personnel to the absence of a safety device.

2. Warning devices

Open-beam systems shall be provided with the following warning devices:

1. X-ray tube status (ON-OFF) located near the X-ray source housing, if the primary beam is controlled in this manner; and/or,
2. Shutter status (OPEN-CLOSED) located near each port on the X-ray source housing, if the primary beam is controlled in this manner.

These devices shall be readily visible and properly labeled as to their purpose. Warning devices shall have fail-safe characteristics.

3. Shutters

Shutters at unused ports shall be secured in the closed position to prevent accidental opening.

4. Ports

Each port on the X-ray source housing shall be equipped with a shutter that cannot be opened unless a collimator or other device has been connected to the port, if the system was installed after January 1, 1980.

Training

All individuals independently operating analytical X-ray equipment shall be designated as "Restricted Users" and shall receive instructions in and demonstrate ability in:

1. General properties of ionizing radiation.
2. Principles of radiation detection.
3. Radiation hazards associated with the use of the equipment.
4. Biological effects of ionizing radiation.
5. Procedures to minimize exposure.
6. Proper operating procedures for the equipment.
7. Purposes and functions of the radiation warning and safety devices incorporated into equipment.
8. Proper procedures for reporting an actual or suspected over-exposure.

Ability shall be demonstrated by passing a written examination administered by the Radiation Safety Officer. Exceptions to radiation safety training will not be granted because of previous education, training, or experience.

Operating Procedures

1. Procedure Manual - Normal operating procedures shall be written and available to all analytical X-ray equipment users. Analytical X-ray equipment shall not be operated differently from that specified in the procedure manual unless written permission has been obtained from the Radiation Safety Officer (RSO).
2. Bypassing Safety Device - A safety device shall not be bypassed unless written approval has been obtained from the Radiation Safety Officer. This approval shall be for a specified time. When a safety device has been bypassed, a conspicuous sign shall be placed on the X-ray housing bearing the words (or similar words), "SAFETY DEVICE NOT WORKING."

Radiation Limits

Enclosed-beam systems

The exposure rate during normal operations shall not exceed 2.5 mrem/hr at a distance of 5 cm from the protective chamber walls.

Open-beam systems

The exposure rate at the maximum rated current and voltage with all shutters closed shall not exceed 2.5 mrem/hr at a distance of 5 cm from the X-ray tube housing.

Generator Cabinet

The exposure rate at a distance of 5 cm from the surface of the X-ray generator cabinet shall not exceed 0.25 mrem/hr.

During normal operations in restricted areas, scattered radiation levels in accessible areas in any one hour shall not exceed 37.5 mrem to the hands or 2.5 mrem to the whole body.

During alignment procedures, the dose equivalent to the hands in any 1 hour shall not exceed 37.5 mrem.

The local parts of an analytical X-ray system shall include sufficient shielding and be so located and arranged so exposure rates in unrestricted areas do not exceed 2 mrem/hr, or 100 mrem in 7 consecutive days, or 500 mrem/yr.

Personnel Monitoring

All workers shall wear a whole-body personnel monitoring device during the operation of the equipment.

Finger dosimetry devices shall be worn by all personnel working with open-beam analytical X-ray equipment.

The College of William and Mary has adopted procedures to keep the exposure to radiation As Low As Reasonable Achievable (ALARA). These procedures employ the practices of reducing the TIME of all exposures, keeping the greatest practical DISTANCE from all sources, using SHIELDING when ever possible, and preventing any exposure to individuals that is greater that 125mR per quarter or totaling more than 500 mR per year.

Surveys

Radiation surveys shall be performed and documented by the Radiation Safety Officer, or alternate RSO:

1. On installation of the equipment and at least once every year thereafter to monitor leakage radiation.
2. On at least an annual basis to monitor area radiation levels when the equipment is operating.

Radiation surveys with a meter capable of detecting x-ray shall be performed and documented by the Restricted User who is approved and supervised by the Radiation Safety Officer or Alternate RSO:

1. Following any change in the initial arrangement, number or type of local parts.
2. Following any maintenance that requires the disassembly or removal of a local part.
3. During the performance of maintenance and alignment procedures that require the presence of a primary beam and the disassembly or removal of a local part.
4. When a visual inspection of the local parts reveals an abnormality. Each area or room containing open-beam analytical X-ray equipment shall be equipped with a suitable radiation survey instrument.
5. To accomplish the required surveys an appropriate survey meter will be available within the facility during all operations. The documentation of all of the surveys described in points 1 through 4 above, will be maintained in the laboratory with the instrument for inspection by the RSO and by the Commonwealth of Virginia.

Repair and Alignment Procedures

The following safety precautions **shall** be taken to reduce risks during repair and alignment procedures:

1. The main switch, rather than the safety interlocks, shall be used to shut down the equipment.
2. No X-ray tube shall be used without a suitable housing to restrict the radiation to a well-defined beam.
3. A sign stating "Interlocks Not Working" must be posted on the equipment when the interlocks have been defeated for alignment purposes.
4. Alignment procedures, other than those recommended by the manufacturer, must be approved by the Radiation Safety Officer.
5. Alignment procedures must be written and available to all users.
6. If the dose rate in an unrestricted area is exceeded during the repair or alignment procedure, temporary barriers must be set up and the area must be properly posted. The area shall be kept under surveillance until normal operations have been restored.
7. After re-assembly, the X-ray equipment shall be checked for leakage radiation by the Radiation Safety Officer or the Restricted User.

The following safety precautions **should** be taken to reduce risks:

1. The smallest practical voltage and current should be used during the alignment procedure.
2. Long-handled tools and extension devices should be used to reduce the risk of the hand entering the beam.
3. Protective glasses should be worn during alignment procedures.
4. Temporary shielding should be added to reduce scattered radiation levels to a minimum.
5. Alignment procedures recommended by the manufacturer should be used.
6. Two-man teams should be used during alignment procedures. One person should make the adjustments while the other person watches for safety problems.

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