University of Pennsylvania

Environmental Health and Radiation Safety (EHRS)

X-ray Diffraction
User Guide

(Reviewed: September 2012)

I. INTRODUCTION

Analytical X-ray machines are defined as an assembly of components that utilize x-rays to determine elemental or chemical composition, or to examine the microstructure of a material through the use of x-ray diffraction or fluorescence.

II. PA DEPARTMENT OF ENVIRONENTAL PROTECTION

Use of x-ray equipment in Pennsylvania is regulated by the PA Department of Environmental Protection (DEP). The DEP has established regulations which must be followed by all individuals using energized (x-ray) equipment. These regulations are found in Title 25 Chapters 219, 220, and 227 of the Pennsylvania Code and are available for review in the Environmental Health and Radiation Safety (EHRS) office, or on the DEP website at http://www.pacode.com/index.html.

III. ENVIRONMENTAL HEALTH AND RADIATION SAFETY (EHRS)

EHRS is responsible for ensuring that radiation and radioactive material is used safely at Penn and associated facilities (e.g., Wistar Institute, CHOP). EHRS staff performs a safety check of each diffraction x-ray unit at installation and annually (at a minimum). If service is provided on the unit that would effect the arrangement, number, or type of components in the system contact EHRS for an additional safety check prior to use. [PA 227.12a]

IV. X-RAY DIFFRACTION UNITS

A. Unit Registration

All analytical energized equipment must be registered with EHRS prior to use. This can be done by contacting EHRS, and must be done at the time of equipment installation. [PA 219.131-2]

B. Unit Acquisition

It is the responsibility of the clinical personnel to notify EHRS upon acquisition of any new x-ray equipment. Authorized EHRS personnel will conduct a radiation safety survey on all new units prior to use.

C. Unit Relocation, Disposal, or Transfer

EHRS must be notified prior to relocation, disposal, or transfer of ownership of cabinet x-ray equipment. Relocation includes moving equipment to a different room within the same building. EHRS will ensure that proper notifications to State Agencies are made. [PA 219.131-2]

V. WORKER RESPONSIBILITIES

A. Worker Training [PA 227.14]

1. Radiation Safety Training

   All persons using x-ray diffraction equipment must attend the radiation safety training specific to this type of equipment. This training is provided on the EHRS website at https://www.ehrs.upenn.edu/radiation-safety/topics/radiation-safety-training

2. Operational Training

   Additionally, all the persons operating the equipment must receive the following instructions from the primary researcher and demonstrate competence in the following areas:

   a. Significance of the various radiation warning and safety devices incorporated into the equipment, or the reason they have not been installed on certain pieces of equipment, and the extra precautions necessary if the devices are absent or bypassed.
   b. Operating and emergency procedures.

VI. RADIATION SURVEY

All x-ray diffraction equipment must be surveyed at the following times [PA227.11a]:

1. Upon installation;

2. Annually;

3. Whenever the following occurs:
   a. When there is a change in the initial arrangement, number, or type of local components in the analytical x-ray system.
   b. Following maintenance requiring the disassembly or removal of a local component.
   c. During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when a local component in the system is disassembled or removed.
   d. When a visual inspection of the local component in the system reveals an abnormal condition.
   e. When the machine is operated in a manner other than the routine manner specified in the written operating procedures.

VII. SAFETY DEVICES AND SIGNS

1. On equipment with an open beam configuration manufactured and installed after December 19, 1987, each port on the radiation source housing must be equipped with a shutter that cannot be opened unless a collimator or coupling has been connected to the port. [PA 227.11a.(c)] ***Note:*** *An open beam configuration system is an analytical x-ray system in which the beam is not enclosed or shielded so any portion of an individual's body, including fingers, could accidentally be placed in the beam path during normal operation.[PA 227.2]*

2. Unused ports on radiation housings shall be secured in the closed position in a manner which will prevent accidental opening. [PA 227.11a.(e)]

3. An open-beam configuration unit must have a device which either prevents the entry of any portion of body into primary beam path or causes the beam to be terminated when a part of the body approaches the beam. [PA 227.11a.(a)]

4. A warning label must be posted on the x-ray source housing which states, "Caution - High Intensity X-ray Beam", and another label which states, "Caution Radiation - This Equipment Produces Radiation When Energized", near any switch that energizes the X-ray tube.[PA 227.11a.(f)] ***Note:*** *These labels are available from EHRS.*

5. An easily visible warning light which does the following [PA 227.11a.(d)]:
    a. Illuminates when the X-ray tube is energized and labeled with the words "X-Ray ON."
    b. Illuminates in each port on radiation source housing when the shutter is open (this applies to open beam configurations).

VIII. OPERATING REQUIREMENTS

Operating procedures must be written and available to the analytical x-ray equipment operators. Procedures must include instructions for the following [PA 227.13a]:

1. Sample insertion and manipulation

2. Equipment alignment

3. Routine maintenance and data recording procedures

An individual may not operate analytical x-ray equipment in a manner other than that specified in the operating procedures unless that individual has obtained written approval from the EHRS Radiation Safety Officer (RSO). Except when written approval is given by the RSO to override safety devices, operations involving removal of covers, shielding materials or tube housings, or modifications to shutters, collimators or beam stops may not be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored.

Interlocks may not be used for routine shutdown in preparation for repairs (i.e. use the main shutdown switch).

IX. OVERRIDING SAFETY DEVICES

An individual may not bypass or otherwise circumvent a safety device unless that person has received prior written approval from the RSO. An approval request form can be found on the EHRS website at https://www.ehrs.upenn.edu/policies-resources/request-interlock-override-approval-x-ray-diffraction-units. [PA 227.13a(b)]

In order to receive written approval, the following will be needed:

1. Whole-body and extremity dosimeters. To request dosimeters, use the same EHRS webpage listed above.

2. Calibrated survey meter that measures milliroentgen per hour (mR/hr).

3. Controls and procedures to assure the safety of individuals during the override.

4. A readily discernible sign bearing the words, **"SAFETY DEVICE NOT WORKING"** to be placed on the source housing.

X. PERSONNEL EXPOSURE MONITORING

Exposure to scattered radiation from analytical x-ray equipment is extremely low. The radiation levels are measured by EHRS, and must not exceed 0.5 mR/hr at 5 centimeters from the surface of the unit for it to be routinely operable. Therefore personnel dosimetry is not required during routine use. [PA 227.32]

However, personnel dosimetry is required for persons performing maintenance on x-ray diffraction units when a local component in the system is disassembled or removed, or when safety devices are disabled. Contact EHRS for dosimeters prior to such maintenance.

XI. EMERGENCY PROCEDURES

If anyone thinks they may have been exposed to the x-ray beam, please contact EHRS immediately. EHRS is required to report suspected overexposures to the DEP within 5 days of the incident, so ***immediate action is required*** by anyone suspecting that they have been exposed to the x-ray beam. [PA 227.14(2)(d)]

XII. IMPORTANT PHONE NUMBERS

University of Pennsylvania, Environmental Health and Radiation Safety:

Monday – Friday during business hours **(215) 898-7187**

On-Call Physicist for assistance after hours **(215) 573-6626**