

ANALYTICAL X-RAY EQUIPMENT

(For assistance, please contact EHS at (402) 472-4925, or visit our web site at <http://ehs.unl.edu/>)

This Safe Operating Procedure (SOP) summarizes those requirements of Nebraska Title 180, **Control of Radiation**, that pertain to analytical x-ray equipment. Most requirements are specified in Title 180, Sections 8 and 15.

DEFINITIONS

- **Analytical x-ray equipment** – equipment used for x-ray diffraction or fluorescence analysis.
- **Analytical x-ray system** – a group of components utilizing x-rays to determine elemental composition or examine the microstructure of materials.
- **Fail-safe characteristics** – a design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam upon failure of safety or warning device.
- **Local components** – part of an analytical x-ray system, including areas that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding; but do not include power supplies, transformers, amplifiers, readout devices, and control panels.
- **Normal operating procedures** – step-by-step instructions necessary to accomplish the analysis. These procedures shall include sample insertion and manipulation, equipment alignment, routine maintenance by the registrant, and data recording procedures that are related to radiation safety.
- **Open-beam configuration** – an analytical x-ray system configured such that an individual could accidentally place some part of his/her body in the primary beam path during normal operation.
- **Primary beam** – radiation that passes through an aperture of the source housing by a direct path from the x-ray tube or a radioactive source located in the radiation housing.

EQUIPMENT REQUIREMENTS

- **Safety Device.** All machines with an open beam configuration must be equipped with a safety device to prevent accidental exposures. The device can be designed to impede placement of the operator's hand or other body part into the beam, or cause the beam to shut-off upon obstruction of the beam path.

- **Warning Devices.** Warning devices must be labeled so that their purpose is easily identified and have fail-safe characteristics. In addition, open-beam configurations must be provided with a readily discernible indication of:
 - X-ray tube status (ON-OFF) located near the radiation source housing, if the primary beam is controlled in this manner.
 - Shutter status (OPEN-CLOSED) located near each port on the radiation source, if the primary beam is controlled in this manner.
- **Ports.** Unused ports on radiation source housings must be secured in the closed position to prevent casual opening.
- **Labeling.** All analytical x-ray equipment must be labeled with readily discernible sign(s) bearing the radiation symbol and the words:
 - “CAUTION – HIGH INTENSITY X-RAY BEAM,” or words having a similar intent, on the x-ray source housing; and
 - “CAUTION RADIATION – THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED,” or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube; or
 - “CAUTION – RADIOACTIVE MATERIAL,” or words having a similar intent, on the source housing if the radiation source is a radionuclide.
- **Shutters.** On open-beam configurations, each port on the radiation source housing must be equipped with a shutter that cannot be opened unless a collimator has been connected to the port.
- **Warning Lights.** Warning lights must have fail-safe characteristics, be labeled with the words “X-RAY ON,” or words having a similar intent, illuminated only when the tube is energized or the shutter is open, and located:
 - Near any switch that energizes an x-ray tube; or
 - In the case of a radioactive source, near any switch that opens a housing shutter.
- **Radiation Source Housing.** Each x-ray tube housing must be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled. Each x-ray tube housing must be constructed so that when all shutters are closed, the radiation leakage measured at a distance of 5 cm from its surface is not capable of producing a dose in excess of 2.5 mrem/hour at any specified tube rating. If radioactive sources are used, corresponding dose limits must not exceed 2 mrem/hour.
- **Generator Cabinet.** Each x-ray generator shall be supplied with a protective cabinet that limits radiation leakage. Leakage shall not exceed that which could produce a dose in excess of 0.25 mrem in one hour when measured at a distance of 5 cm from the cabinet’s surface.

AREA REQUIREMENTS

- **Radiation Levels.** The local components of an analytical x-ray system must be located, arranged, and include sufficient shielding or access control so that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits specified

in Title 180, **4-013**. For systems utilizing x-ray tubes, these levels apply to any specified tube rating.

- **Surveys.** Surveys of analytical x-ray systems are performed by EHS staff at the following frequencies:
 - Upon installation of the equipment and at least once every 12 months thereafter.
 - Following any change in the initial arrangement, number, or type of local components in the system.
 - Following any maintenance requiring the disassembly or removal of a local component in the system.
 - Any time a visual inspection of the local components in the system reveals an abnormal condition.
- Note: It is the responsibility of the registrant to notify the EHS Radiation Safety Office of the need for any such surveys.***
- **Posting.** Each area or room containing analytical x-ray equipment must be conspicuously posted with a sign or signs bearing the radiation symbol and the words “CAUTION – X-RAY EQUIPMENT,” or words having a similar intent.

OPERATING REQUIREMENTS

- **Procedures.** Normal operating and emergency procedures must be written and available to all analytical x-ray equipment workers. No person shall operate analytical x-ray equipment in any manner other than that specified in the procedures.
- **Bypassing.** A safety interlock may only be bypassed with written approval from the Radiation Safety Officer and for a specific period of time. When approved, a sign must be placed on the machine indicating the device is disabled.
- **Repair/Modification.** The Radiation Safety Officer is to be notified and the main switch turned off prior to repairs or modifications to the tube, shielding materials, housing, or cover (including removal).

PERSONNEL REQUIREMENTS

- **Training.** Three types of training are required of x-ray equipment operators:
 - ***Initial X-ray Radiation Safety Training*** (presented by Radiation Safety office staff and consisting of typical radiation protection topics).
 - ***Initial X-ray Instrument Specific Training*** (presented by the Authorized User/Registrant and consisting of instrument-specific operating and emergency procedures).
 - ***Annual Refresher X-ray Safety Training*** (presented by the Radiation Safety Officer).
- **Personnel Monitoring.** Operators are required to wear whole body badge and ring dosimeters when operating the x-ray equipment. Dosimetry are exchanged on a quarterly basis with EHS. ***Operators shall immediately notify EHS if a dosimetry badge or ring is lost (EHS will issue replacements).***