

ANALYTICAL X-RAY EQUIPMENT AND OTHER COMMON RADIATION GENERATING EQUIPMENT

This Safe Operating Procedure (SOP) summarizes regulatory and UNL policy requirements to possess and operate analytical x-ray equipment and other common non-healing arts radiation generating equipment. The analytical x-ray equipment discussed in this SOP includes:

- X-ray diffractometers (XRD)
- X-ray fluorescent devices (XRF)
- Hand-held X-ray fluorescent devices
- Educational analytical x-ray equipment

Educational analytical x-ray equipment is a subset of “analytical x-ray equipment” that consists of low current XRF or XRD used for educational purposes only. No research is performed using this equipment. Training and dosimetry requirements differ for educational analytical x-ray equipment.

Other common non-healing arts radiation generating equipment discussed in the SOP includes:

- Electron microscopes
- X-ray photo-spectrometers
- Cabinet x-ray systems

NOTE: there are other types of radiation generating equipment (e.g., particle size analyzer) that are not addressed by this SOP. At a minimum, purchase/installation of ANY radiation generating equipment must be approved by the Radiation Safety Office.

Definitions

Useful regulatory definitions from Nebraska Title 180, Control of Radiation that apply to the use of analytical x-ray equipment are provided below.

Analytical x-ray equipment means equipment used for x-ray diffraction or fluorescence analysis.

Analytical x-ray system means a group of components utilizing x-rays to determine elemental composition or examine the microstructure of materials.

Cabinet x-ray system means an x-ray system with the x-ray tube installed in an enclosure that is independent of existing architectural structures except the floor. The cabinet x-ray system is intended to contain at least that portion of a material being irradiated, provide radiation attenuation, and exclude personnel from its interior during generation of radiation.



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Included are all x-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad, and bus terminals, and in similar facilities. An x-ray tube used within a shielded part of a building, or x-ray equipment which may temporarily or occasionally incorporate portable shielding is not considered a cabinet x-ray system.

Fail-safe characteristics means a design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam upon failure of safety or warning devices.

Local components mean 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 mean 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 means 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 means 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.

Authorization to Possess or Operate Analytical X-Ray Equipment

Operation of analytical x-ray equipment must be performed under the supervision of an individual that has been approved by the UNL Radiation Safety Committee (RSC). The approved individual or Authorized User (AU) must be a faculty or staff member knowledgeable in the operation of analytical x-ray equipment.

To become an AU:

1. Complete EHS Radiation Safety training for x-ray users.
2. Complete vendor-provided equipment training for hand-held x-ray systems.
3. Complete an Authorization Application. Obtain an Authorization Application by contacting the Radiation Safety Office. Authorization applications require Department Head concurrence.
4. Complete and submit normal operation procedures to the Radiation Safety Office.
5. Commission the analytical x-ray equipment and operating location through inspection by the Radiation Safety Office.
6. Obtain approval from the UNL RSC.

NOTE: Use of analytical x-ray equipment in an open beam configuration (such as a hand-held XRF) requires UNL to apply for an exemption from the regulatory requirement for a safety device. This exemption must be granted by Nebraska Department of Health and Human Services before the equipment can be operated. This request must include



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a description of the alternative methods that will be employed to minimize possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

State Registration for Analytical X-Ray Equipment

All analytical x-ray equipment must be registered with the Nebraska Department of Health and Human Services, Office of Radiological Health within 30 days of receipt, change in location or disposal. The Radiation Safety Office maintains this registration. The AU shall promptly notify the Radiation Safety Office of any such changes. Receipt of new equipment will require a commissioning inspection by the Radiation Safety Office.

Training Requirement for Analytical X-Ray Equipment

AUs must complete EHS Radiation Safety training for X-ray users and complete annual refresher training. Radiation Workers (RW) are individuals that are approved to use analytical x-ray equipment under the supervision of the AU, including student laboratory instructors.

RWs must complete the following training:

- EHS Radiation Safety Training for X-ray users.
- Training on normal operating procedures for the specific equipment to be used.
- Annual Radiation Safety refresher training.
- Additional vendor-provided equipment training may be required by the RSO.

Students participating in a laboratory class which uses educational analytical x-ray equipment require the following training:

- EHS Radiation Safety training lecture.
- Training on normal operating procedures used in the laboratory class.

Training on normal operating procedures is provided by the AU or a designated RW who has completed all training requirements and is knowledgeable in operation of the equipment. Training on normal operating procedures must be completed in a timely manner following EHS provided training. Dosimetry is not issued until all training is completed. Documentation upon completion of training must be provided to the Radiation Safety Office. Training documentation is not necessary for students participating in a laboratory class which uses educational analytical x-ray equipment.

Radiation Surveys and Inspections for Analytical X-Ray Equipment

At a minimum, Radiation Safety Office staff will inspect analytical x-ray equipment annually to evaluate compliance with regulatory requirements. These routine inspections will be scheduled with the AU. X-ray operation by the AU or RW will be required during the inspection.

Additional radiation surveys are required by regulation under certain circumstances. If any of the circumstances listed occur, it is the responsibility of the AU to promptly notify the Radiation Safety Office to schedule a radiation survey:



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- Upon installation of new equipment or removal of the equipment from a “lockout” configuration.
- Following any change in the initial arrangement, number or type of local components in the system.
- Following any maintenance requiring disassembly or removal of a local component in the system.
- Any time a visual inspection of local components in the system reveals an abnormal condition.

Normal Operating Procedures for Analytical X-Ray Equipment

Written step-by-step instructions necessary to accomplish the analysis are required for each analytical x-ray device and must be available to all RWs and students, as applicable. These procedures must provide instruction for sample insertion and manipulation, equipment alignment, routine maintenance, and any data recording procedures that are related to radiation safety.

The AU is responsible to ensure no individual operates the analytical x-ray equipment in any manner other than that prescribed in the normal operating procedures.

Any procedure, maintenance or alignment that requires access to the primary x-ray beam with any local component of the system disassembled or removed, requires prior approval by the UNL Radiation Safety Office.

Dosimetry for Analytical X-Ray Equipment

All approved operators of analytical x-ray equipment will be issued dosimetry consisting of a torso badge and finger ring badge. Detailed instructions for proper use of dosimetry is provided in the EHS SOP, **Dosimetry Program**. Students participating in laboratory courses involving infrequent use of educational analytical x-ray equipment will not be issued dosimetry.

Dosimetry is sent to the appropriate department for distribution to the AU and their RWs.

Dosimetry for new RWs will be sent following successful completion of all previously discussed training requirements.

Analytical x-ray equipment shall not be operated without properly worn dosimetry. If dosimetry is lost, the Radiation Safety Office shall be promptly notified and replacement dosimetry will be issued. Dosimetry is exchanged on a quarterly basis (monthly for fetal dosimeters). It is the responsibility of the AU to ensure dosimetry is returned to the Radiation Safety Office in a timely manner for processing.

Electron Microscopes (EM)

Upon installation, an initial radiation survey must be conducted by the Radiation Safety Office to determine the regulatory status of the EM. If the incidental radiation dose equivalent rate averaged over an area of 10 cm² does not exceed 0.5 mrem/hour at 5 cm from any accessible surface, then the following procedure applies:



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- Contact EHS to initiate registration with the Radiation Safety Office (State registration is not required).
- Approval by the RSC is not required.
- EHS Radiation Safety training is not required.
- Operators are expected to follow manufacturer's normal operating procedures.
- Dosimetry is not required.
- The Radiation Safety Office will perform an annual physical inventory of the EM.
- Promptly notify the Radiation Safety Office if the EM is modified (e.g., addition of a XRF) or relocated.

If the incidental radiation dose equivalent rate exceeds 0.5 mrem/hour or the EM includes an XRF or XRD, then all applicable Analytical X-ray Devices steps must be followed.

X-Ray Photoelectron Spectroscopy (XPS)

The procedure for an XPS is similar to that of an EM. Upon installation, an initial radiation survey must be conducted by the Radiation Safety Office to determine the regulatory status of the XPS. If the incidental radiation dose equivalent rate averaged over an area of 10 cm² does not exceed 0.5 mrem/hour at 5 cm from any accessible surface, then the following procedure applies:

- Contact EHS to initiate registration of the XPS with the Radiation Safety Office and the State of Nebraska Department of Health and Human Services.
- Approval by the RSC is not required.
- EHS Radiation Safety training is not required.
- Operators are expected to follow manufacturer's normal operating procedures.
- Dosimetry is not required.
- The Radiation Safety Office will perform an annual physical inventory of the XPS.
- Promptly notify the Radiation Safety Office if the XPS is modified or relocated.

If the incidental radiation dose equivalent rate exceeds 0.5 mrem/hour or the XPS includes an XRF or XRD, then all applicable Analytical X-ray Devices steps must be followed.

Cabinet X-Ray Systems

The following procedure must be followed when using a cabinet x-ray system:

- Authorized users of cabinet x-ray systems must be approved by the RSC. Follow the instructions for **Authorization to Possess or Operate Analytical X-ray Equipment** described above.
- Cabinet x-ray systems require State registration. Follow the instructions for **State Registration for Analytical X-ray Equipment** described above.
- EHS Radiation Safety training is not required. However, operators shall receive training to normal operating procedures and safety devices. This training is provided by the AU or a designated RW who has completed all training requirements and is knowledgeable in the operation of the cabinet x-ray system. Annual refresher training is required, provided by the AU or qualified RW as previously described. Documentation upon completion of training must be provided to the Radiation Safety Office.
- Dosimetry is not required to operate cabinet x-ray systems.



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- Testing for proper operation of interlocks must be conducted and recorded at intervals not to exceed 6 months. This testing is performed by the Radiation Safety Office.
- An annual radiation survey must be conducted by the Radiation Safety Office to demonstrate the radiation dose equivalent rate averaged over an area of 10 cm² does not exceed 0.5 mR/hour at any point 5 cm outside the external surface.
- Promptly notify the Radiation Safety Office if the cabinet x-ray system is modified or relocated.

Reporting of Suspected Beam Exposure

Exposure to the primary x-ray beam is unlikely if the requirements of this SOP and normal operating procedures are strictly followed. If you suspect that a part of your body has been exposed to the primary x-ray beam, report the suspected exposure immediately to your AU and the Radiation Safety Office at (402) 472-4925 to initiate an exposure investigation.