

CHAPTER 12 RADIATION-PRODUCING EQUIPMENT

1.0 PURPOSE AND SCOPE

The purpose of this chapter is to provide instruction for the use and control of radiation-producing equipment at the University of Georgia. The information in this chapter is based on the requirements set forth by federal agencies and the Georgia Department of Natural Resources and Department of Human Resources. This chapter applies to all personnel working under the UGA radiation safety program.

Radiation-producing equipment is defined as any equipment that produces or contains sources of ionizing radiation. This equipment may be used in the disciplines of the healing arts (i.e., medicine, osteopathy, dental or veterinary) or non-healing arts (industry, education or research). In most cases, equipment covered under this procedure contains a sealed source of radiation or an x-ray-producing vacuum tube or housing. Industrial products and manufactured equipment containing exclusively exempt quantities of radioactive material are excluded from the requirements of this chapter.

2.0 PRECAUTIONS AND LIMITATIONS

- Radiation shall not be applied to human beings except as prescribed by persons licensed to practice in the healing arts. Human medical use regulations are outside the scope of this document.
- The operation of any radiation machine in the state of Georgia is prohibited unless the user and equipment is registered with the Department of Human Resources.
- No routine operations should be conducted that would require an individual to expose any part of their body to the primary beam of a radiographic device, unless that individual is a patient in a healing arts procedure.
- Unqualified personnel must not attempt to remove sealed sources from instruments, equipment, or housings. This task must be performed by authorized personnel or qualified vendors. Contact Radiation Safety for specific information.
- No one is permitted to open or breach the containment of any radioactive sealed source contained in radiation-producing equipment. Potentially serious radiological consequences could occur.
- Non-radiological safety hazards (mechanical, electrical, etc.) may be associated with radiation-producing equipment and are beyond the scope of this chapter.

3.0 GENERAL INFORMATION

3.1 X-ray-Generating Equipment

Like gamma radiation, x-rays are a type of ionizing electromagnetic radiation. X-rays are produced when charged particles, usually electrons, are accelerated in a vacuum by an electrical voltage. The electrons interact with a target material, resulting in a release of energy from the target in the form of x-rays. Examples of this equipment include x-ray machines, fluoroscopes, and equipment that may produce x-rays as an unwanted by-product, such as electron microscopes.

When x-rays interact with any material, some x-rays may pass completely through the material, some may depart all of their energy within the material, and some will scatter. The scattering effect occurs when x-rays “bounce off” surfaces and results in the majority of exposure to personnel operating radiographic equipment.

3.2 Sealed Source Irradiators

Sealed source irradiators typically consist of a shielded radiation source that can be mechanically activated (unshielded) to cause a target to be exposed. When in the shielded mode (off position) radiation levels are usually minimal. The type and energy of radiation emitted is dependent on the isotope used as a source. Gamma-emitting isotopes with relatively long half-lives are commonly used.

3.3 Radiation Safety Considerations

Radiation safety measures for radiation-producing equipment include the following:

- access controls
- training of personnel
- appropriate use of time, distance, and shielding (see Chapter 9, *Laboratory Procedures*)
- radiological postings
- warning indicator lights that alert personnel when equipment is operational
- mechanical interlocks on doors and access panels to prevent x-ray production during personnel access
- periodic testing and maintenance to ensure that equipment is operating properly.

4.0 REGISTRATION OF RADIATION-PRODUCING EQUIPMENT

All instrumentation or equipment capable of producing ionizing radiation must be registered with Radiation Safety. Registration is made by completing the registration form (or an approved equivalent) provided as an attachment to this chapter. The form should be sent to Radiation Safety a minimum of 10 days before the instrument is placed in service at UGA. All information on the registration form should be complete and accurate. The individual primarily responsible for use and/or ownership of the equipment will be considered the registered user. At the time of this writing, the State of Georgia Department of Human Resources is registering only facilities instead of individual machines, with each new building of the University of Georgia being considered a new facility. Radiation Safety notifies the State of Georgia at the time of completion of each new facility and its radiation-producing equipment, as well as giving the State an annual list of changes to existing equipment and facilities and any new machines obtained.

It is the responsibility of the individual owner/user to ensure that his equipment is properly registered with the Department of Human Resources by notifying Radiation Safety upon its acquisition and about any changes to its room or facility.

Radiation-producing equipment that contains radioactive sources is subject to the authorization, procurement, control, and disposal requirements for radioactive materials as described in this Radiation Safety Manual.

Radiographic equipment is not subject to the radioactive materials requirements of this manual.

5.0 TRAINING

Radiation Safety can provide training in the fundamentals of radiation safety and basic x-ray safety. Training in proper operation and safety for specific equipment must be performed or supplied by the registered user/primary operator. The registered user must maintain documentation adequate to assure the Department of Human Resources that all radiation machines and associated equipment under the control of the registered user are operated only by individuals instructed in safe operating procedures. Instruction must begin within 30 days after employment and be completed no later than 90 days after date of employment. Prior to the completion of training, direct guidance (i.e. continuous supervision) by qualified individuals should be provided to any un-trained personnel.

5.1 Training of Operators who Administer X-rays in the Healing Arts

The registered user must ensure that persons operating his/her radiation machine and associated equipment receive, at a minimum, six hours of instruction. The following subject categories are to be covered:

- 1) Protection Against Radiation
 - a) Protective Clothing
 - b) Patient-Handling
 - c) Time, Distance, Shielding
 - d) Radiation Protection Standards
- 2) Dark Room Techniques (if applicable)
 - a) Developing Chemicals
 - b) Film Protection
 - c) Cassettes
 - d) Screens
- 3) Patient Protection
 - a) Beam Limitation
 - b) Setting Up Techniques
 - c) Biological Effects of Radiation
- 4) Machine Safety
 - a) Machine Functions
 - b) Safety Procedure
 - c) Recognizing Problems

5.2 Training of Operators Who Work With Radiation-Producing Machines in All Other Applications (Non-Healing Arts)

The registered user must ensure that persons operating his/her radiation machine and associated equipment receive, at a minimum, two hours of instruction in the following six subject categories:

- 1) Fundamentals of Radiation Safety
 - a) Characteristics of radiation
 - b) Units of radiation measurement
 - c) Significance of radiation dose and exposure (radiation protection standards and biological effects)
 - d) Sources and levels of radiation
 - e) Methods of controlling radiation dose (time, distance, and shielding)
- 2) Radiation Detection Instrumentation to be Used
 - a) Use of radiation survey instruments (operation, calibration, limitations)
 - b) Use of personnel monitoring equipment (dosimetry)
- 3) Radiographic Equipment to be Used
 - a) Remote-handling equipment
 - b) Radiographic exposure devices and sealed sources
 - c) Operation and control of x-ray equipment
- 4) Pertinent Federal and State Regulations
- 5) The Registered Users Written Operating and Emergency Procedures
- 6) Case Histories of Radiography Accidents

6.0 PERSONNEL EXPOSURE LIMITS

The requirements of Chapter 3, *Radiation Exposure Limits*, must be complied with. In addition, users of radiographic equipment must comply with the following exposure limits.

Table 6
Radiographic Equipment Quarterly Exposure Limits

Location	mrem/Quarter Limit
Whole body; head and trunk; active blood forming organs; lens of eyes; or gonads	1250 mrem
Hands and forearms; feet and ankles	18,750 mrem
Skin of the whole body	7500 mrem

- Individuals under 18 years of age shall be limited to 10% of the limits in Table 6.

- Radiation exposure to declared pregnant women shall comply with the requirements of Chapter 3, *Radiation Exposure Limits*.
- Patients undergoing procedures in the healing arts are exempt from these exposure limits.
- Radiation exposure rates in unrestricted areas shall be such that, if an individual were continuously present in the area, the exposure to that individual would not exceed 2 mrem in any one hour or 100 mrem in any 7 consecutive days.

7.0 PERSONNEL MONITORING

Radiation monitoring dosimetry is required for all individuals:

- likely to receive 25% of the limits specified in Table 6
- entering high radiation areas
- under 18 years of age in x-ray training schools or employed in occupations that involve exposure to radiographic equipment
- using non-medical x-ray devices who are likely to receive 25 mrem per week.

When using protective aprons, personnel dosimetry shall be worn outside the apron at collar level.

For additional information about procurement and control of personnel dosimetry, see Chapter 9, *Laboratory Procedures*.

8.0 SAFETY REQUIREMENTS FOR RADIATION-PRODUCING EQUIPMENT

- 1) Facilities considerations, including design requirements must comply with the Rules and Regulations for X-Rays, Chapter 290-5-22 and must ensure that the radiation exposure limits for unrestricted areas described in section 6 of this chapter are met. Where appropriate, a qualified expert should be consulted in the design of new facilities or in the modification of existing facilities.
- 2) Installation, calibration, maintenance, repairs, testing, and radiological monitoring must be performed by qualified personnel. Vendors and associated personnel responsible for these duties must keep documentation adequate to show evidence of compliance with the rules and regulations.
- 3) Radiation-producing equipment shall be tested prior to initial use, after the performance of any modifications, maintenance, or repairs with the potential to affect safety, at any time an abnormal condition is noted, and in accordance with regulatory requirements.
- 4) Equipment warning labels and labels that contain information related to the make, model, or manufacturer of radiation-producing equipment are to be maintained in a legible condition. Refer to Chapter 7, *Radiological Postings*, for information regarding radiation warning signs, labels, and postings.
- 5) The registered user is responsible for maintaining appropriate documentation in support of regulatory compliance.

- 6) A copy of the state of Georgia Rules and Regulations for X-Rays, Chapter 290-5-22 should be in the possession of all registered users (preferably at the work location) and all applicable personnel shall comply with it.
- 7) Radiation-producing equipment capable of generating a high radiation area (100 mrem/hr @ 30 cm from the source of radiation) must be kept locked or otherwise controlled to prevent unauthorized access.
- 8) The useful beam of radiographic equipment shall be limited to the smallest area practicable, consistent with the objectives of the radiological examination or treatment.
- 9) All interlocks, shutters, dead-man switches, beam-limiting devices, collimating devices, filters, primary and secondary barriers, and fail-safe devices shall be used or installed in accordance with regulatory requirements, must be properly maintained, and cannot be modified in any way that would compromise their safety or effectiveness.
- 10) X-ray films, intensifying screens, and other image-recording devices should be as sensitive as is consistent with the requirements of the examination or procedure being conducted.
- 11) Particular care should be taken to align the x-ray beam to ensure that only the target area is irradiated and to reduce the need for performing more procedures than necessary.
- 12) Only persons whose presence is necessary may be allowed in radiographic areas during exposure.
- 13) Protective clothing, in the form of gloves and aprons with a shielding ability of at least 0.25mm lead equivalent, should be provided and worn in radiographic areas during exposure, except when individuals are entirely behind a protective barrier.
- 14) Radiographic equipment, as well as image-processing and film devices, should be maintained under a quality control program adequate to minimize the unproductive use of radiation.
- 15) Fluoroscopic equipment used in the healing arts is required to have periodic measurements performed of the Entrance Exposure Rate (exposure rate at the point where the center of the useful beam enters the patient) and the exposure rate at staff positions around the table and panel. These measurements are required to be performed on an annual basis and after the performance of any maintenance that might affect the exposure rate.
- 16) Radiation-producing equipment used for therapeutic purposes is required to be calibrated on an annual basis. Spot-check measurements are required on a periodic basis. Therapeutic radiographic equipment operating at energies ≥ 1 Mev must be calibrated by a qualified expert and have spot-check measurements reviewed by a qualified expert. The training and experience requirements for a qualified expert are described in Rule 290-5-22-.04(18)(e) of the Rules and Regulation for X-Rays.
- 17) In veterinary applications where an animal patient must be held or positioned manually, the individual holding the animal shall wear protective gloves having at least 0.5 mm lead equivalency and a protective apron of at least 0.25 mm lead

equivalency. Even when using protective clothing, exposure of personnel to the primary beam must be avoided.

- 18) Radiography or teletherapy devices containing sealed radioactive sources must have a durable, legible, and clearly visible label describing the isotope, activity, assay date, manufacturer, and model or serial number of the device. Source assemblies, shields, shutters, etc. are to be properly maintained and cannot be modified in any way that would compromise their effectiveness. The sealed radioactive source of all devices in active use must be leak-tested at a minimum frequency of every 6 months.
- 19) Equipment that produces x-rays as an unwanted by-product, such as electron microscopes and cathode-ray tubes, is not allowed to exceed a radiation dose rate of 0.5 mR/hr at a distance of 5 centimeters (2 inches) from any readily accessible point.

10.0 TRANSFER AND DISPOSAL OF RADIATION-PRODUCING EQUIPMENT

10.1 Transfers of Radiographic Equipment

Radiation Safety should be notified prior to the transfer of radiographic equipment from one registered user to another or to an off-campus location. The registered user on file with Radiation Safety is responsible for initiating this notification. Appropriate paperwork will need to be filed with the Department of Human Resources to reflect the change in registration for the radiographic equipment.

10.2 Disposal of Radiographic Equipment

Radiographic equipment that is to be disposed of (not transferred) must be rendered inoperable to ensure that it will not be a danger to unqualified personnel. Contact Radiation Safety for guidance in proper disposal of this equipment.

10.3 Transfer and Disposal of Equipment Containing Radiation Sources

The requirements for transfer of radioactive materials are described in Chapter 5, *Procurement and Transfer of Radioactive Materials*. For disposal of radiation sources contact the Radiation Safety staff and refer to Chapter 10, *Radioactive Waste Handling and Disposal*.

11.0 ATTACHMENTS

Radiation-Producing Equipment Registration Form (example)