THE UNIVERSITY *of* NORTH TEXAS
HEALTH SCIENCE CENTER *at* FORT WORTH

X-Ray Safety

hsc THE UNIVERSITY of NORTH TEXAS HEALTH SCIENCE CENTER at FORT WORTH

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Radiation Producing Equipment

Any device that can produce ionizing radiation when the related control devices are activated is referred to as a radiation-producing machine.

A radiation-producing device that complies with the requirement that all areas with exposure rates greater than 0.25 mR/hr be enclosed within an interlocked barrier is known as a closed system. The rest are regarded as open systems.

High-energy electrons collide with a metal target in an X-ray tube to produce X-rays in diagnostic radiography. The machine only emits X-rays when it is turned on. The patient is not rendered radioactive. X-ray images are viewed on a video monitor rather than film in diagnostic fluoroscopy.

Fluoroscopy procedures are the most common source of occupational radiation exposure in the medical field. Fluoroscopy is used to investigate moving structures as well as to assess positioning during surgical and radiographic procedures. The portable fluoroscopy unit is also known as a "c-arm." All X-ray machines are "registered" with the Texas Department of State Health Services (DSHS), the state radiation protection regulatory agency.

Linear accelerators (powerful X-ray machines) are used in radiation therapy to treat cancer. The radiation produced by these units has 10 to 100 times the energy of a diagnostic x-ray machine. Linear accelerators can use either X-rays or electrons to treat patients.

Fetal Protection Policy

Recent research has revealed that a mother's significant radiation exposure during pregnancy increases the risk of childhood leukemia and other cancers.

According to a report from the National Academy of Sciences, if children were exposed to 1 rem (1000 millirems) of radiation before birth (a rem is a unit used to measure radiation dose in the human body), the incidence of leukemia among children from birth to age 10 could increase from 3.7 cases per 10,000 to 5.6 cases per 10,000. The Academy also estimates that this level of radiation could cause an equal number of other types of cancer. Although other studies have found a much smaller effect from radiation, each woman should be aware of any potential risk so that she can take whatever precautions she believes are necessary to protect her children.

It is the policy of HSC to safeguard the fetus or embryo of expectant workers who are exposed to ionizing radiation at work. If a worker informs her employer in writing that she is pregnant, federal and State (Texas's) radiation protection laws limit the occupational dose to pregnant women to 500 millirems throughout the pregnancy. This value is one-tenth of the adult-specific annual exposure limit. The average annual dose from natural radiation sources is about 300 millirem, which can help put things into perspective.

When an employee decides to announce her pregnancy, she should let her manager know so that they can set up a meeting with the Radiation Safety Officer (RSO) to go over potential safeguards to reduce radiation exposure. You can get pregnancy declaration forms from the RSO or can be downloaded/printed from Appendix XI page 81 of the Radiation Safety Manual.

The RSO will review the work assignments and history of radiation exposure, and if necessary, he or she may recommend limitations in the work assignment. The assignment of dosimeters will be followed by a monthly review of radiation exposures. Employees who work with radioactive materials might also be put on a routine bioassay program.

Radiation Producing Machines Policies and Procedures

It is the responsibility of the Principal Investigator (PI) to guarantee that only authorized users are permitted to use their equipment. Individuals listed on the initial application or those who are added using the New Radiation Worker Form are considered authorized users.

Before independently operating a radiation-producing machine, new employees must successfully demonstrate their understanding of operating and safety procedures under the supervision of the PI (or another qualified experienced operator designated by the PI).

New employees may be required to attend an x-ray safety training session offered by the EH&S and/or pass a brief written test to prove their understanding of operating and safety procedures, depending on prior experience and the type of machine to be operated.

Posting

Each laboratory with a radiation-producing machine must have a sign with the radiation symbol and the words CAUTION X-RAYS posted at the entrance. The PI's or designee's name and after-hours phone number must be shared with safety personnel and appropriate personnel.

Each machine's control device must have a label attached that reads CAUTION THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED (or words to that effect).

On or close to the tube of an X-ray machine, a label with the words CAUTION HIGH-INTENSITY X-RAY BEAM (or words to that effect) must be attached.

To show when X-rays are being produced, an X-RAY ON warning light/sign that is labeled with its meaning must be installed on or close to an X-ray tube.

Access Control

Each machine requires the maintenance of key control. This requirement may be met by restricting access to the lab for older machines without keyed control devices. An operator must be present or the lab must be kept locked while any open system is in use.

Operating Procedures

Each machine's operating procedures must be available near the machine. These procedures must specifically include:

(a) means to control and limit doses to individuals, including controlling access to the area, and

(b) the use of radiation survey instruments and dosimeters in open systems.

Safe Operating Guidelines for X-Ray Machines

a) When working with radiographic/fluoroscopic equipment, personnel monitoring devices should always be worn.

i. For workers who wear only one device, the devices worn should be those issued for the current time period and should be worn at the collar.

ii. For workers who have been issued two personnel monitoring devices, one should be worn at the collar and the other under the lead apron at the waist.

b) Only those who need to be there should be in the radiographic or fluoroscopic room during exposure. All such people who are exposed to direct scatter radiation must wear aprons or whole-body protective barriers of at least 0.25 mm lead equivalent.

i. A 0.25 mm lead equivalence lead apron reduces scattered x-rays by 95%. Furthermore, the shielding integrity of protective shielding devices must be evaluated annually.

c) When an image/object receptor must be held in position for radiography or fluoroscopy, mechanical supporting or restraining devices must be used.

i. If an image/object must be held by an individual, that individual must be shielded with appropriate shielding devices of at least 0.25 mm lead equivalence for whole-body protection and at least 0.5 mm lead equivalence for any part of the holder's body exposed to the primary x-ray beam.

ii. Preferably, the person holding the image/object is a radiation worker.

iii. In general, x-ray technicians should not hold an image/object during X-ray exams, it is in use.

d) Exposure should be kept to a bare minimum in accordance with regulatory principles.

i. For each x-ray tube capable of producing radiographic exposures, technique charts indicating the set of factors (kVp, mAs) that typically yield the optimal exposure for a body part of a specific size and orientation should be available.

ii. Technique charts should be used when appropriate.

e) The x-ray beam should be collimated to the smallest area consistent with requirements and accurately aligned with the patient and image receptor at all times.

f) Mobile equipment should be used only when it is impractical to transfer patients/objects to permanent radiographic facilities.

g) Gonadal shielding of at least 0.5 mm of lead equivalent shall be used for potentially procreative patients during radiographic procedures in which the gonads are in the direct or useful beam, unless the clinical objectives of the examination are jeopardized.

i. Gonadal shielding should never be used in place of careful patient positioning and adequate beam limitation.

h) Use the smallest practical field sizes and exposure times possible. (With the exception of breathing technique studies, which may necessitate longer exposure times.)

i. As long as image quality is not compromised, the possibility of reducing dose using techniques utilizing high tube potential (kVp) and low current (mA) should be considered.

i) During radiographic exposures at permanent radiographic installations, the operator must stand behind the barrier provided for his/her protection.

i. The DEXA suite is exempt from this requirement because the operator remains in the room during radiographic exposures and wears a lead apron. DEXA equipment operators should keep at least 6 feet away from the patient during exposures, or as far away as possible due to room space constraints.

ii. When operating mobile equipment, operators should stand as far away from the patient/object as possible (at least 6 feet).

j) Exposures must be performed with the x-ray room doors closed. When individuals are in or near the doorways of these areas, exposures should be avoided.

k) Prior to making an exposure, each mobile radiographic equipment operator should ask anyone within 6 feet of the x-ray tube and/or patient being radiographed to move further away until the exposure is complete.

i. Those who must remain within 6 feet of the patient/object and/or x-ray tube must wear whole-body aprons or barriers with a lead equivalence of at least 0.25 mm. Before the exposure, the operator must issue an audible warning.

l) The exposure rate used in fluoroscopy should be as low as possible while still meeting fluoroscopic requirements, and should normally not exceed 10 R/min (measured in air) at the point where the beam enters the patient.

i. To optimize performance and minimize patient dose, it is usually best to use fluoroscopic machines with the "automatic brightness system" turned on.

m) Fluoroscopy should not be used as a substitute for radiography, but rather for the study of dynamics or spatial relationships, or for guidance in the recording of critical details on spot film.

n) Medical fluoroscopy should be performed only by or under the direct supervision of fluoroscopically trained physicians.

o) The fluoroscopist's hand should not be placed in the useful beam unless the beam is attenuated by the patient and a protective glove with a lead equivalent of at least 0.5 mm.

p) When using tube currents and potentials that are higher than those normally used in fluoroscopy, special precautions should be taken to limit patient exposure.

q) Film processing materials and techniques should be those recommended by the x-ray film manufacturer or those that have been tested to ensure that the developed x-ray film has the highest information content possible. HSC employs quality control methods to ensure the best possible results.

Surveys
The PI must provide a radiation survey meter for open systems in order to detect the presence of unwanted radiation and trace the source of radiation leaks. A Geiger-Mueller survey meter with a thin window probe is recommended.

Before turning on the machine after altering the experimental set-up, the operator must visually check ports, cameras, shielding, etc.

Following the activation of the machine, a radiation survey should be performed to check for scattered or leakage radiation.

Unused Ports
All unused X-ray ports must be permanently blocked or interlocked so that if the port is opened, x-ray production is halted. The material used to block unused ports must be dense and thick enough to attenuate the primary beam to acceptable levels.

Shielding
In open x-ray systems, protective barriers and/or shielding must be used to ensure that exposure rates in accessible areas are less than 2 mR/hr at 5 cm from any exterior surface. It is critical to keep the shielding free of cracks and gaps.

Log Book
A log book must be kept for open systems, which records the following information: operator, data, voltage, current, exposure time, and radiation survey results.

Dosimetry
The RSO will establish dosimetry requirements after reviewing each facility.

Dosimeters will not be issued to users of electron microscopes or other enclosed systems in general.

A personnel dosimeter will be issued to anyone using an accelerator, a radiographic unit, or an open system x-ray diffraction unit. When the machine is running in the facility, this dosimeter should be worn at the collar or at the level of the chest. The personnel dose from exposure to the primary beam will not be measured by the dosimeter; it will only measure scattered radiation.

EH&S may install area dosimeters throughout the facility. Laboratory staff should not move these dosimeters.

Radiation Safety Survey
Radiation Safety personnel inspect radiation-producing machines when they are first installed, at yearly intervals, and whenever significant changes are made to the machine, facility, or operating procedures.

Facility Design
Every year, HSC conducts tests to ensure that all x-ray-producing machines meet the performance and use standards outlined in state and federal regulations. From these tests, exposures and exposure rates typically experienced are identified.

Every radiographic and fluoroscopic facility is built so that no single public member or someone exposed at work will receive an annual radiation dose that exceeds the annual dose limits (0.1 rem) allowed by state regulations.

X-ray Equipment Administrative Policy
The purpose of this policy is to ensure that all ionizing radiation-producing equipment is safe and meets applicable Federal and State standards after receipt and installation within the HSC system.

1. Building or renovating facilities to house X-ray equipment

Any remodeling, alterations, or building projects involving ionizing radiation-producing machinery must be planned and built in accordance with all applicable radiation safety regulations. The RSO interprets the standards as determined by the State of Texas. The RSO must be involved in early planning sessions, mailings, and plan reviews for all relevant projects. The RSO must review all final construction drawings for such facilities or alterations before they are released for bid, and a shielding plan review must be documented and filed with the state regulatory agency. Furthermore, during construction, any deviations from the approved shielding plan must be reviewed by the RSO. During construction, the RSO will inspect the shielding assembly to ensure proper installation. The completed facility will be subjected to a full radiation safety acceptance survey.

2. Ionizing Radiation Producing Equipment Registration

   The RSO must register all ionizing radiation-producing equipment under the jurisdiction of the HSC system with the State of Texas regulatory agency within 30 days of initial operation. The RSO must be notified when this type of equipment is received.

3. Relocation, Storage, or Disposal of X-ray Equipment

The RSO must approve any activity (other than routine maintenance) involving the modification, relocation, storage, or disposal of ionizing radiation-producing equipment. Following the

completion of the activity, the RSO must make the necessary determinations to ensure the safe operation of modified or relocated equipment. To maintain a current x-ray equipment registration with the State of Texas regulatory agency, the RSO must also be notified of surplused, resold, or dismantled equipment.

4. Responsibility of Reporting to the RSO

The following responsibilities are assigned to ensure proper communication with the RSO regarding the aforementioned issues:

a) The RSO or designee should attend diagnostic radiology quality control meetings.

b) HSC or the Facilities Department's Electrical Engineering section is responsible for notifying the RSO of any renovations or new construction that will include ionizing radiation-producing equipment.

c) Each department that uses ionizing radiation is responsible for identifying and designating a contact person, who is then responsible for informing the RSO of any activities within their department that involve radiation-producing equipment. Purchases of new equipment, modifications, relocations, evaluating loaned equipment, and disposal of equipment are examples of such activities.

Important!
Any unusual or dangerous condition involving radiation sources should be reported to the RSO.

During normal duty hours, any non-emergency questions should be directed to the RSO/EH&S or Campus Police.

Call the RSO for more information on radiation exposure during pregnancy. To keep your radiation exposure as low as reasonably achievable (ALARA), use time, distance, and shielding, as well as disposable gloves and lab coats.

EH&S has access to the HSC Radioactive Materials licenses, x-ray registrations, regulations, inspection reports, and exposure reports.