King Abdulaziz University
Faculty of Dentistry

Radiation Safety Manual

FOR X-RAY EQUIPMENT OPERATORS

October 2009

Radioactivity and Radiation

All matter in our environment is made of atoms. Most atoms we encounter on Earth are stable. Some atoms, however, are unstable, giving off energy in the form of radiation in order to reach a stable state. These atoms are said to be radioactive. An example is the radionuclide, Carbon-14, produced in the atmosphere when cosmic rays interact with stable nitrogen atoms. When a Carbon-14 atom undergoes radioactive decay, it gives off radiation in the form of a beta particle and then becomes a stable nitrogen atom once again. The existence of Carbon-14 in all living things enables archaeologists to date ancient artifacts.

Radiation can be naturally-occurring or produced electrically, as in an x-ray tube. Radiation can only be detected by specially designed instruments. Radiation may pass through an object, but it may be absorbed and cause changes at the site of absorption. Radiation is known to cause cancer and birth defects in animals and humans. The risk of radiation damage is related to the amount of radiation absorbed by an individual. With the amounts of radiation encountered by employees and students at King Abdulaziz University Faculty of Dentistry, the risk is very small.

There are small amounts of naturally-occurring radioactive substances in soil, rocks, plants, animals, and in our own bodies, all of which give off radiation. Large amounts of radiation are present in outer space and a small portion of this radiation penetrates the atmosphere. This low level of naturally occurring radiation is known as background radiation.

Radiation is useful in dentistry because of its ability to penetrate tissue, allowing imaging of internal structures. However radiation may produce harmful biological effects. Observations of exposed human populations and animal experimentation indicate that exposure to low levels of radiation over a period of years may lead to an increase in the incidence of cancer and leukemia. Exposures to high levels of radiation produce the same effects faster and may also cause hair loss, skin burns, radiation sickness or even death. Radiation may also increase the risk of genetic abnormalities.

Radiation Protection at the Faculty of Dentistry

To minimize the biological effects of radiation, special rules and regulations are set forth for individuals occupationally exposed to radiation. The amount of radiation received by persons exposed occupationally should not exceed the dosages specified in the National Guidelines for Protection against Ionizing Radiation (from King Abdulaziz City for Science and Technology KACST). These regulations and other information is available at http://www.kacst.edu.sa.

There is, in general, minimal external radiation hazard to personnel from procedures involving radiation. Adherence to guidelines contained in this manual will help all x-ray equipment operators keep their exposures as low as reasonably achievable (ALARA), and for most students and staff members should reduce radiation exposures to levels allowable for individual members of public or in some cases, to levels indistinguishable from natural background.

Radiation safety services are provided for the Faculty of Dentistry by the KAU Radiation Safety Committee. These services include the oversight and administration of the personnel monitoring program, area surveys and x-ray equipment inspections, and training of employees. Questions regarding safety may be directed to the following individuals:

> Dr. Emad Khan or Dr. Soad Mansour at Ext. 20017, or
> Radiation Safety Officer (RSO) at Ext. 68280 (KAU Radiation Safety can be reached after normal working hours via Civil Defense emergency number at 998).

All operators of x-ray machines are responsible for following radiation safety procedures described in this manual.

Generating X-Rays

In *diagnostic radiography*, x-rays are produced when high-energy electrons collide with a metal target in an x-ray tube. X-rays are only produced when the machine is activated. The patient does not become radioactive.

In the x-ray tube, electrons are generated at the filament end of the x-ray tube by thermionic emission (boiling of electrons from the filament). They are then given kinetic energy by applying a high voltage between the filament and the target. If a voltage of 100,000 volts (100 kVp) is applied to the x-ray tube, the electrons will strike the target producing x-rays with energies from 0 to 100 keV. Note: kVp is the voltage applied to the x-ray tube and keV is the energy of the x-ray. The low energy x-rays can not get out of the x-ray tube so the actual spectrum of x-rays ranges from about 10 keV to 100 keV. The higher the x-ray energy, the higher its ability to penetrate tissue. As the kVp increases so does the intensity of the x-ray beam, i.e. more x-rays of all energies are generated.

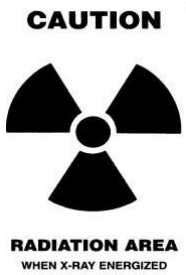
- The energy of the x-rays is determined by the voltage applied to the tube, kVp.

- The quantity of x-rays is determined by the milliamps (mA) of current flowing in the x-ray tube (and also by the tube voltage).

The higher the mA, the higher the radiation dose to the patient. One of the factors that affect image quality is the number of x-rays reaching the film. Image contrast is the difference in the number of photons that get through the various parts of the body being imaged. The higher the kVp, the more photons that get through, resulting in less differentiation between tissues (contrast).

The goal is to keep the mA as low as possible and the kVp as high as possible to achieve a compromise between the number of photons reaching the film and optimum image (contrast).

Because radiation cannot be seen or felt, the radiation symbol is used to alert you to its presence. All rooms or areas where radiation-producing equipment is used are posted with this sign.



(magenta or black with a yellow background)

Basic Radiation Safety Procedures

The radiation protection program is guided by the concept of keeping radiation exposure As Low As Reasonably Achievable (**ALARA**). The ALARA concept is based on the assumption that any radiation dose, no matter how small, can have some adverse effect. Under the ALARA program, every reasonable means of lowering exposure is used. Radiation exposure can be minimized by utilizing three basic principles:

1) **Time:** Shorter exposure time means a lower dose.

2) **Distance:** Doubling the distance from a radiation source means one-fourth the dose rate. Tripling the distance gives one-ninth the dose rate.

3) **Shielding:** The use of appropriate shielding greatly reduces the dose rate. Standing in a protected area during x-ray exposures is one example.

Remember that radiation cannot be seen or felt, but can be detected with radiation survey meters.

Dose Limits/Monitoring Requirements

The average annual dose of a radiation worker at KAU Faculty of Dentistry is **less than 100 millirem**. A radiation worker is required to be monitored if he/she is **likely** to receive in excess of 10% of the dose limits. Those dose limits are:

Whole Body:	*5,000 millirem/year*	*Skin/Extremities:*	*50,000 millirem/year*
Lens of Eye:	*15,000 millirem/year*	*Fetus:*	*500 millirem/gestation*

An individual member of the public is allowed only 100 millirem per year from all licensed and registered radiation activities. Keep in mind, however, that the average Saudi citizen receives about 360 millirem of radiation each year from "background" radiation sources and medical procedures. (That's the equivalent of about 36 chest x-rays!)

Personnel radiation monitoring will be offered to those individuals who frequently make exposures or supervise radiography students and request such service. Radiation exposure is monitored with a TLD (Thermo-Luminescence Dosimeter) (badge). If assigned a badge:

- Always wear the badge when working around radiation sources and make sure it is the badge assigned to you.
- Wear the badge on your collar. If you wear a lead apron, the badge shall be worn outside of the apron.
- When not in use, store badges at work in a low radiation area, do not wear your badge outside of the work place.

The control badge shall also be stored in a radiation-free area. An assigned radiologic technologist is responsible for the exposure records and exchanging the badges.

Action levels have been set which trigger investigations to determine if the exposures were as low as reasonably achievable. If not, recommendations are made to ensure that future exposures are ALARA.

Try to keep your personal radiation exposure as low as you can. Be aware of where you are standing and how long you stay in the radiation area. **Do not enter or remain in a radiation area unless it is necessary.** If you suspect there has been an excessive exposure or radiation incident, immediately notify the RSO.

Guidelines for Safe Operation of X-Ray Equipment

- All radiographs shall be prescribed by faculty members and/or graduate students holding the B.D.S. degree (or equivalent) and who are licensed to practice dentistry within the Faculty of Dentistry.

- Only qualified and authorized persons shall expose patients to ionizing radiation. Students who have obtained radiographic pre-clinical competence will be allowed under faculty supervision. Students shall be closely supervised by faculty or staff during all clinical radiographic procedures conducted on patients. Exposures shall be made only after faculty authorization. The retaking of radiographs shall be authorized and supervised by a faculty member. Patients shall not be subjected to retakes to satisfy technical perfection.

- Students shall not serve as live technique mannequins and shall not expose each other unless clinically indicated.

- Patients shall not be subjected to administrative radiographs prior to initial screening and consultation.

- Radiographs shall be limited to the minimum number needed to obtain diagnostic information required for the patient's dental needs and should follow ADA/FDA guidelines for prescribing dental radiographs.

- The x-ray equipment in this facility was installed following the manufacturer's specifications. Do not alter, tamper with, or remove any of the filters or collimators, or in any way cause needless radiation exposure.

- We have established a restricted area(s) in the room in which the x-ray equipment is located when the machine is in operation. The restricted area(s) is (are) always inside the operatories or immediately adjacent to the source. There are signs found next to the exposure controls providing appropriate operational instructions.

- Do not allow anyone in the room with the patient during an x-ray examination. Use mechanical holding devices when a patient or the image receptor must be held. If other persons are needed for the examination, they **must** wear a protective lead apron. They must follow safe radiation procedures and keep out of the direct beam. The protective equipment is stored in every x-ray room and operatory. Note: A lead apron of 0.25 mm lead equivalence will reduce scattered x-rays by 95%. Individuals who hold patients will be selected on the basis of skill and number of times they

have held patients. The same person is not allowed to regularly hold patients, should not be pregnant or potentially pregnant, and is over the age of 18.

- Never hold the tube housing or the support housing during any exposure. The tube housing must not drift or move during the exposure. If a problem with stability of the suspension arm develops, notify the RSO.

- Stay in the control booth (station, behind the barrier, etc.) during each exposure. Always maintain visual and aural contact with the patient through the leaded glass, or mirror by providing the appropriate instructions. When operating mobile equipment, the operator should stand as far as possible (at least 6 feet) from the patient.

- For extraoral systems restrict the x-ray beam to the area of clinical interest. The beam size must not be larger than the image receptor.

- Use the technique chart or manual to determine proper exposure (time, kilovoltage, etc.). Don't depend on memory for the proper technique. The technique chart should be updated as needed.

- Portable or mobile equipment shall be used only for examinations where it is impractical for medical reasons to transfer the patient to a stationary radiographic installation.

- Film processing shall take place using the time/temperature processing method and shall be monitored on a daily basis to assure film quality. Digital imaging equipment shall be monitored on a regular basis to assure image quality.

- All significant data derived from radiographs shall be entered in the file of the patient. All radiographs shall be identified with patient's name, dated, mounted and filed in the patient's chart as they become available.

Fetal Protection Policy

King Abdulaziz University has adopted a policy to protect the fetus/embryo of pregnant employees exposed to ionizing radiation in their work. Regulations limit the occupational dose to pregnant women to 500 millirems over the course of the pregnancy if the worker declares her pregnancy in writing to the employer.

If an employee decides to declare her pregnancy, she should notify her supervisor who will arrange for her to meet with the RSO to discuss possible precautions to limit radiation exposure. The RSO will review work assignments and radiation exposure history, and may recommend limitations in work assignment if necessary. A radiation monitor will be assigned, with radiation exposures to be reviewed monthly.

Special Considerations

Each x-ray tube is tested annually for compliance with performance and use criteria as specified by national regulations. Exposures to which patients are normally subjected are determined from these tests.

Each x-ray facility is designed such that no individual member of the public or a person who is occupationally exposed will receive an annual radiation dose in excess of the annual dose limits as specified in national regulations.

All ionizing radiation producing equipment under the jurisdiction of Faculty of Dentistry must be tested, accepted and registered with the national regulatory agency by the RSO within 30 days of initial operation. The receipt of equipment of this type shall require notification to the RSO.

Important!

Report any unusual or unsafe condition involving radiation to the Radiation Safety Officer (RSO) at 68280. Any non-emergency questions during normal duty hours may be directed to the RSO or either Dr. Emad Khan or Dr. Soad Mansour at 20017. KAU Radiation Safety Committee can be reached after normal working hours through Civil Defense emergency number at 998.

For information about radiation exposure during pregnancy, call the Radiation Safety Officer.

Use Time, Distance and Shielding, to keep your radiation exposure **A**s **L**ow **A**s **R**easonably **A**chievable.

A copy of the National Regulation for Protection against Ionizing Radiation is always available for review in the RSO office.

The KAU Faculty of Dentistry x-ray registrations, regulations, inspection reports and exposure reports are available for review in the KAU University Radiation Safety Committee.