Lec8: Radiation Protection

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❖ **Sources of Radiation in a Dental Radiology:**

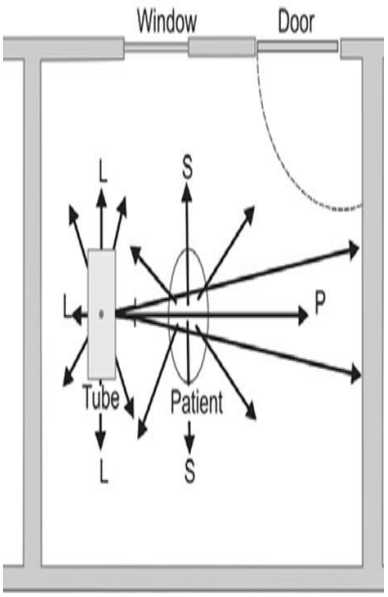
1. Primary beam which is radiation originating from the focal spot.

2. Scattered or secondary radiation is a form of secondary radiation resulted from the interaction of the useful beam and the patient's face.

3. Leakage or stray radiation from the X-ray tube head housing.

4. Scattered radiation from filters and cones.

5. Scattered radiation coming from the objects other than the patient such as the walls and furniture that the primary beam may strike.



Radiation protection:

Radiation protection is the science and practice of protecting people and the environment from the harmful effects of ionizing radiation. According to the ICRP, the System of Radiological Protection is based on the following three principles: ***justification, optimisation of protection and dose limitation*** known as **(ALARA principle means: As Low As Reasonably Achievable).**

❖ Maximum Accumulated Dose (MAD)

Occupationally exposed workers must not exceed an accumulated lifetime radiation dose. This is referred to as the **maximum accumulated dose (MAD)**. MAD is determined by a formula based on the worker's age. To determine the MAD for an occupationally exposed person, the following formula is used:

$$MAD = (N-18) \times 5 \text{ rem/year}$$
$$MAD = (N-18) \times 0.05 \text{ Sv/year}$$

where N refers to the person's age in years. (Note that the number 18 refers to the minimum required age of a person who works with radiation.)

The average permissible dose for such persons is 0.05 Sv/year. From the formula it is clear that individuals younger than 18 years of age should not be employed in the radiology. The various methods adopted for radiation protection should be directed at:

- The patients on whom diagnostic radiographic examination is performed
- The operator associated with the process of radiography
- Others who are not associated with radiography.

Patient Protection

In patient protection, the objective is to use the least amount of radiation to achieve the maxim diagnostic results. The patient must be protected from excessive or unnecessary primary radiation and the resulting secondary (scatter) radiation. This goal can be met by adhering to the **ALARA principle (concept)**, through the use of: safe, well-calibrated x-ray machines, rectangular collimation, receptor-holding devices, fast-speed film or digital imaging, lead aprons and thyroid collars, rare earth intensifying screens, proper shielding, effective chairside and darkroom techniques, and sound professional judgment in selection criteria.

Primary radiation is the x-rays that come directly from the target of the x-ray tube. The primary radiation is collimated by the lead diaphragm, and its softer, fewer penetrating wavelengths are removed by aluminum filters; it then can be referred to as the **useful beam**.

All other radiation can be considered **secondary radiation**. Secondary radiation is defined as radiation that comes from any matter struck by primary radiation. Secondary radiation, besides being harmful to both patient and operator, can degrade the diagnostic image, because the scattered rays produce "film fog" on the radiographic image.

Patient protection techniques can be used before, during, and after exposure to x-radiation.

1. Before Exposure

Patient protection measures can be used before any x-radiation exposure. Proper prescribing of dental radiographs and the use of proper equipment.

A. Prescribing Dental Radiographs

The first important step in limiting the amount of x-radiation received by a dental patient is the proper prescribing, or ordering, of dental radiographs. The person responsible for prescribing dental radiographs is the dentist. The dentist uses professional judgment to make decisions about the number, type, and frequency of dental radiographs. A radiographic examination should never include a predetermined number of radiographs, nor should radiographs be taken at predetermined time intervals. For example, the dentist who prescribes a set number of radiographs (e.g., four bite-wings) at a set interval (e.g., every 6 months) for every patient is not taking the individual needs of the patient into consideration.

B. Proper Equipment

Another important step in limiting the amount of x-radiation is the use of proper equipment. The dental x-ray tube-head must be equipped with appropriate aluminum filters, lead collimator, and position-indicating device.

1) Filtration:

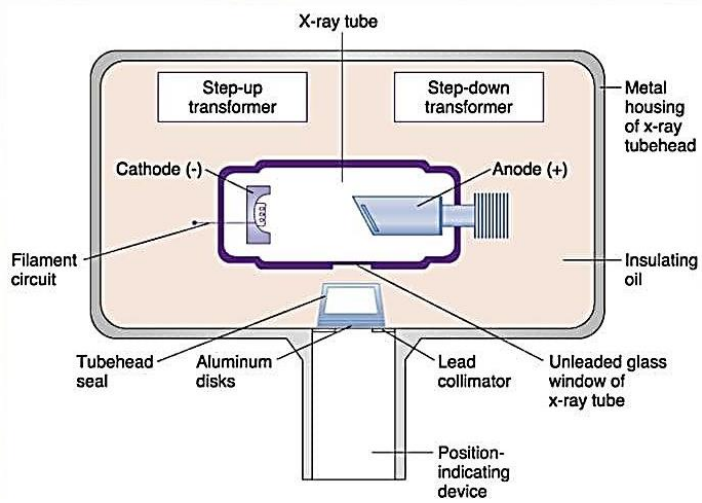
The purpose of **filtration** is to remove the long (soft), nonpenetrating x-ray photons from the x-ray beam. These long wavelength photons either would be absorbed by the overlying tissues or give rise to secondary (scatter) radiation to the patient and degrade the diagnostic image.

Two types of filtration are used in the dental x-ray tube-head: inherent filtration and added filtration.

Inherent filtration takes place when the primary beam passes through the glass window of the x-ray tube, the insulating oil, and the tube-head seal and equivalent to 0.5 to 1.0 mm of aluminum and does not meet the standards alone. Therefore, for x-ray units operating at a kilovoltage below 70, aluminum discs (equivalent to 0.5

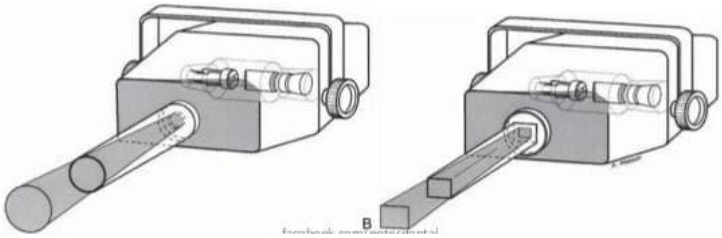
mm aluminum each) are added to produce a total filtration **(inherent plus added filtration)** up to 1.5 mm. For units operating at 70 kV or higher, the total aluminum filtration must be at a minimum of 2.5 mm with added aluminum discs.

• kV lower than 70 = 1.5 mm of total aluminum filtration • kV at 70 or higher = 2.5 mm of total aluminum filtration

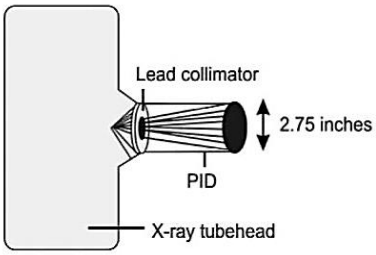


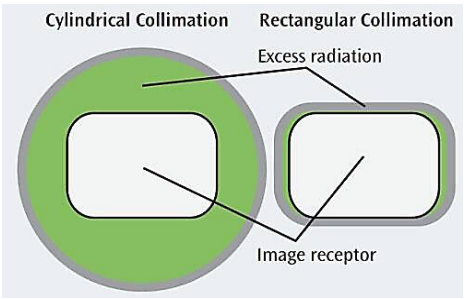
2) Collimation:

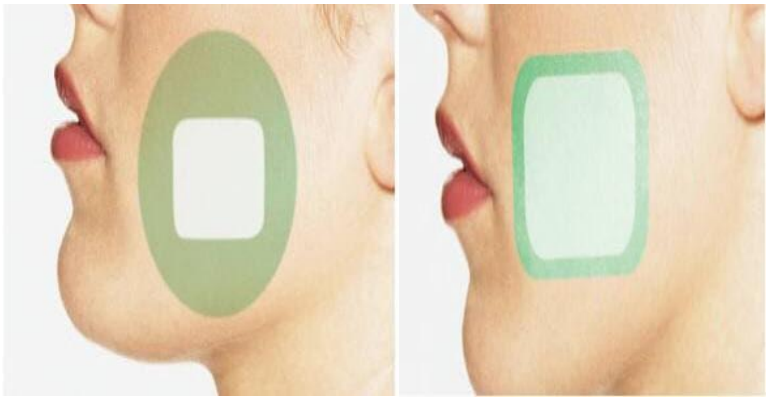
used to restrict the size and shape of the x-ray beam and to reduce patient exposure. A collimator may have either a circular (round) or rectangular opening and are matched with a round or rectangular PID.



- **A circular collimator:** produces a cone-shaped beam that is 2.75 inches in diameter, considerably larger than a size 2 intraoral receptor.
- **A rectangular collimator:** restricts the size of the x-ray beam to an area slightly larger than a size 2 intraoral receptor and significantly reduces patient exposure to 60% less tissue than a circular collimator.





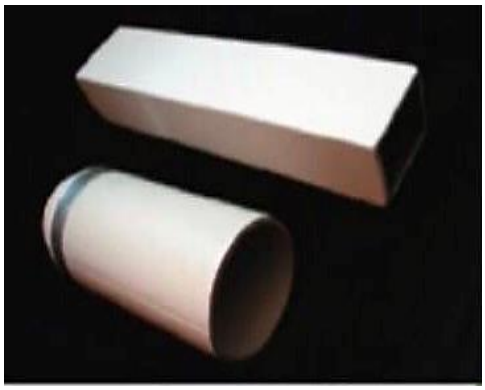


3) Position-Indicating Devices:

Open-ended, lead-lined (shielded) rectangles or cylinders are the only types of position indicating devices (PIDs) that should be used. The use of closed-ended, pointed cones is contraindicated due to increasing scatter radiation to the patient because of the interaction of the primary beam with the closed end of the cone. Conversely, the use of open-ended, lead-lined rectangular or cylindrical (round) PIDs reduces the production of scatter radiation to the patient.

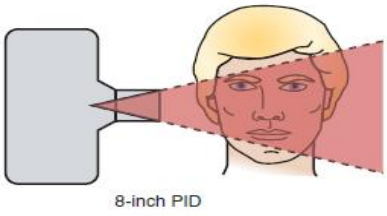
Both rectangular and round PIDs are typically available in two lengths: short (8-inch) long (16-inch).

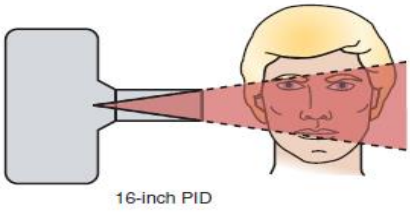
- ✓ The long PID is preferred because less divergence of the x-ray beam occurs.
- ✓ The rectangular PID type is most effective in reducing patient exposure.

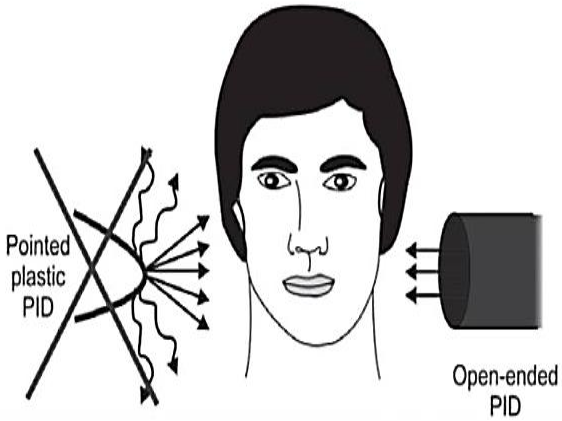












2. During Exposure

Patient protection measures are used during x-ray exposure as well as before exposure. **A thyroid collar, lead apron, fast film or digital imaging, beam alignment devices, exposure factor selection, and proper technique** are all used during x-ray exposure to limit the amount of radiation received by the patient.

Proper selection of exposure factors and good technique further protect the patient from excessive exposure to x-radiation.

A. Thyroid Collar:

The thyroid collar is a flexible lead shield that is placed securely around the patient's neck to protect the highly radiosensitive tissues of thyroid gland from scatter radiation. The thyroid collar may exist as a separate shield or as part of the lead apron. The thyroid gland is exposed to x-radiation during oral radiographic procedures because of its location. The use of the thyroid collar is recommended for all intraoral exposures. However, use of the thyroid collar is not recommended with

extraoral exposures because it obscures information and results in a nondiagnostic image.





B. Lead Aprons:

The lead apron is a flexible shield placed over the patient's chest and lap to protect the reproductive and blood-forming tissues from scatter radiation; the lead prevent the radiation from reaching these radiosensitive organs. The aprons available are usually the equivalent of 0.25-mm lead or lead equivalent, relatively flexible, and not too uncomfortable for the patient.

Recently lead-free aprons made of alloy sheeting have become available for use during intraoral or panoramic radiography. Without the weight of lead, these aprons weigh (30% less and are comfortable and easy to handle while providing the same protection as does the traditional lead apron.

The dose to the gonads is very small during dental exposures but can be reduced even further with the lead apron. The use of lead aprons and thyroid collars can reduce radiation to the thyroid and gonads by up to 94%.





C. Fast film:

Is the most effective method of reducing a patient's exposure to x-radiation and it is available for both intraoral and extraoral radiography.

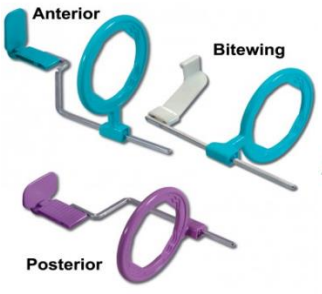
F-speed film, or InSight, is the fastest intraoral film available. Before the introduction of F-speed film, **E-speed film**, or Ektaspeed, was the fastest film available. F-speed film provides (an additional 20% reduction in exposure over E-speed films and 60% reduction in exposure from earlier **D-speed film**, or Ultra-Speed).

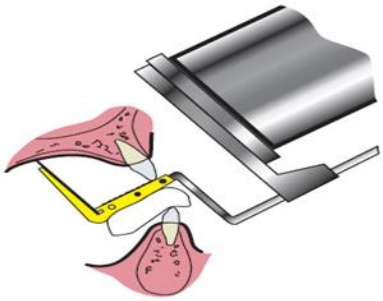
When compared with traditional film radiography, digital imaging requires less radiation exposure of the patient. The lowered absorbed dose is significant with regard to patient protection from excessive radiation. The use of digital imaging can reduce the patient's radiation exposure by up to 90% (when compared to the use of D speed film).

Extraoral projections (e.g., panoramic radiographs, lateral skull projections, etc.) should always be done using the fastest intensifying screen available with its respective compatible film. The use of intensifying screens reduces radiation exposure to the patient by providing exposure of the film to both x-radiation and the light emitted by the phosphor on the intensifying screen. Subsequently, the exposure time is decreased, thereby decreasing radiation exposure to the patient.

D. Receptor (Film) Holders:

Film holders that align the x-ray beam with the receptor in the patient's mouth should be used. These **film-holding devices** (receptor-holding devices) also act to reduce the possibility of collimator cutoff. These devices can be used with circular and rectangular collimation and with conventional or digital imaging. A receptor holder should never be held in place for the patient by the operator or by patients themselves.







E. Exposure Factor Selection

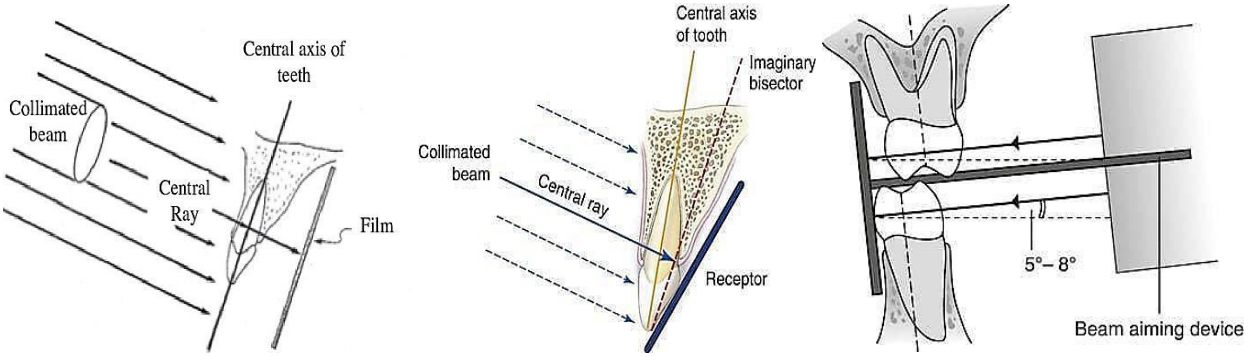
Exposure factor selection also limits the amount of x-radiation exposure to the patient. The dental radiographer can control the exposure factors by adjusting the kilovoltage peak, milliamperage, and time settings on the control panel of the dental x-ray machine. A setting of 70 to 90 kVp keeps patient exposure to a minimum. On some dental x-ray units, the kilovoltage peak and milliamperage settings are preset by the manufacturer and cannot be adjusted.



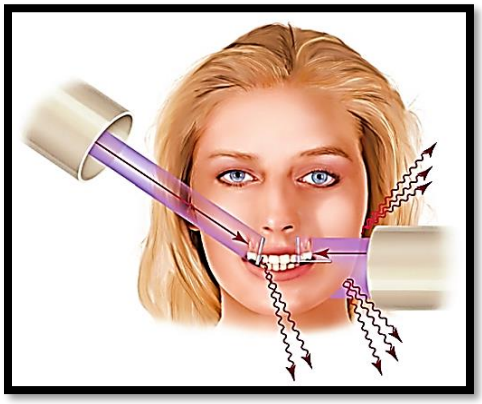
F. Proper technique:

Helps ensure the diagnostic quality of images and reduce the amount of exposure to the patient. Images that are not diagnostic must be retaken; this results in additional exposure of the patient to radiation. Retakes must be avoided at all times. To produce diagnostic images, the radiographer must have a thorough knowledge of the techniques most often used in dental radiography.

Common approaches are :
A) Paralleling technique .
B) Bisecting technique .
C) Bite-wing technique.



Paralleling Technique producing a more accurate diagnostic image with dimensional accuracy, the paralleling technique results in lower dose levels to the thyroid gland and the lens of the eye. In the paralleling method, the x-ray beam for all projections is very close to being parallel to the floor, whereas the bisecting method results in an x-ray beam that has steep vertical angulations that may put the thyroid gland and lens of the eye in the path of the primary x-ray beam as well as the secondary (scatter) radiation.



3. After Exposure

The radiographer's role in limiting the amount of x-radiation received by a patient does not end during exposure. After the receptors have been exposed, they must be handled and processed. Proper handling and processing techniques are critical for the production of high-quality diagnostic images.

1) Proper Film / Sensor Handling

Proper film and/or sensor handling is necessary to produce diagnostic images and to limit patient exposure to x-radiation. From the time the receptors are exposed until they are processed or retrieved, careful handling is crucial. Artifacts caused by improper handling result in non-diagnostic images. A nondiagnostic image must be retaken, which exposes the patient to excessive radiation.

2) Processing / Image Retrieval

Proper film processing (developing) and proper retrieval of digital images are also necessary to produce diagnostic images and to limit patient exposure to x-radiation. Improper film processing or image retrieval can render images

nondiagnostic, thereby requiring retakes and needlessly exposing the patient to excessive x-radiation.

3) Viewing Finished Radiographs

To obtain maximum diagnostic yield for the radiation expended, the manner of **film viewing** for interpretation is extremely important. The only proper way to view a conventional radiograph is in front of an illuminator (view box), preferably with a variable light source. Using sunlight in front of a window or the lamp on the dental unit is unsatisfactory. Ideally, radiographs should be viewed in a darkened room to avoid excessive reflection when this can be achieved in the average dental facility.

Operator Dosage and Protection

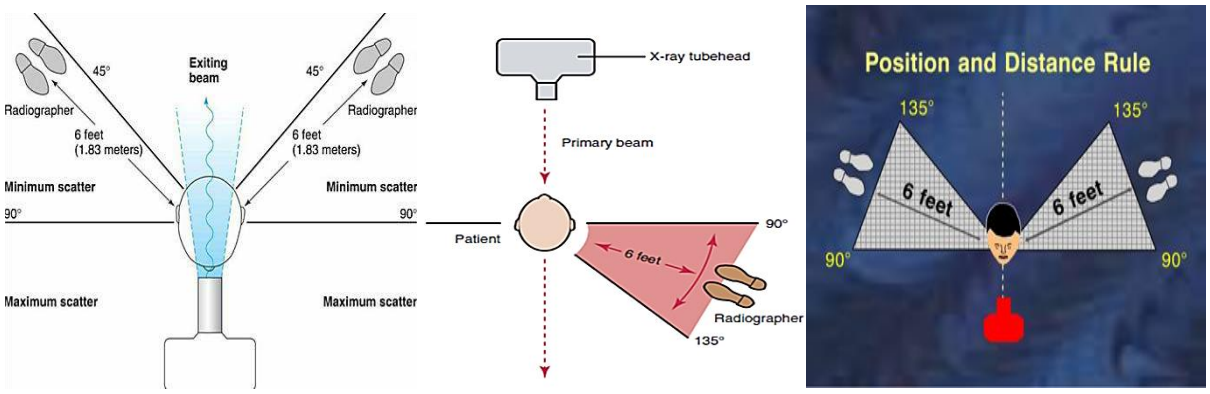
The sources of potential exposure to the dental professional are the primary beam, head leakage from the tube, and secondary (scatter) radiation originating from the patient, x-ray machine, or objects in the operatory. Through the use of careful technique in a well-designed, well-equipped, and well-monitored office, the occupational exposure of dental professionals to ionizing radiation can be kept to a minimum. In the fact, the occupational dose should be zero.

1) Distance Recommendations

One of the most effective ways for the operator to avoid the primary beam and limit x-radiation exposure is to maintain an adequate distance during exposure. The dental radiographer must stand at least 6 feet away from the x-ray tube-head during x-ray exposure. When maintaining this distance is not possible, a protective barrier must be used.

2) Position Recommendations

Another important way for the operator to avoid the primary beam is to maintain proper positioning during x-ray exposure. To avoid the primary beam, which travels in a straight line, the dental radiographer must position perpendicular to the primary beam, or at a 90-degree to 135- degree angle to the beam.



If one's occupational dose is zero, any downward change in the MPD would produce no cause for concern because zero is zero.

Zero exposure is not difficult to achieve in a dental facility that is well designed, well equipped, and well monitored.

A dental professional should not fear working with x-rays but should be knowledgeable regarding their safe use and potential abuse.

Exposure Technique Dental professionals (including dentists) should never be in the path of the primary beam. They should not hold any receptor (film packet, digital sensor, or phosphor plate) in the patient's mouth nor should a drifting tube head be held by the dental radiographer, patient, or any other person (e.g., patient's companion). There should not be any exceptions to this rule.

In general, for proper **exposure technique**, the operator should be a minimum of 6 feet (2 meters) away from the tube head (the source of radiation) and behind a suitable (acceptable) barrier when the exposure is made. It is important for the operator to know the areas of minimum scatter. These areas are at right angles (perpendicular) to the x-ray beam and toward the back of the patient. The areas of highest scatter are in back of the tube head and behind the patient. Also, operators must make sure that coworkers are not in the way of the primary beam or scatter radiation. Operators should check that the work area in all directions is clear before pressing the exposure button.

3) Shielding Recommendations

Adequate shielding can greatly reduce the occupational exposure of the dental radiographer. **Protective barriers** that absorb the primary beam can be incorporated into the office design, thus protecting the operator from primary and scatter radiation. Whenever possible, the dental radiographer should stand behind a protective barrier, such as a wall, during x-ray exposure. Most dental offices incorporate adequate shielding in walls through the use of several thicknesses of common construction materials such as drywall.

4) Radiation Monitoring

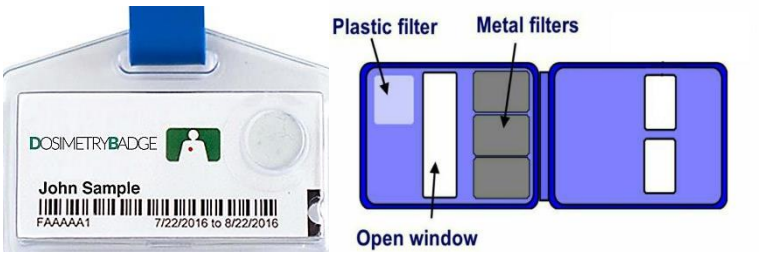
Radiation monitoring can also be used to protect the dental radiographer and includes the monitoring of both equipment and personnel. The use of radiation monitoring can identify excessive occupational exposure.

a) Equipment Monitoring

Dental x-ray machines must be monitored for leakage radiation. **Leakage radiation** is any radiation, with the exception of the primary beam, that is emitted from the dental tube-head. For example, if a dental x-ray tube-head has a faulty tube-head seal, leakage radiation results. Dental x-ray equipment can be monitored for leakage radiation through the use of a film device that can be obtained through the state health department or from the manufacturers of dental x-ray equipment.

b) Personnel Monitoring

The amount of x-radiation that reaches the body of the dental radiographer can be measured through the use of a personnel monitoring device known as a **radiation monitoring badge**.



A radiation monitoring badge can be obtained from *a badge service company*. The radiation monitoring badge consists of a piece of radiographic film in a plastic holder. Each radiographer should have his or her own badge; the badge should be worn at ***waist level*** whenever the dental radiographer is exposing x-ray films or digital sensors. When badges are not worn, they should be stored in a radiation-safe area. A radiation monitoring badge should never be worn when the radiographer is undergoing x-ray exposure. After the dental radiographer has worn the badge for a specified interval (e.g: 1 month), the badge is returned to the service company. The company processes and evaluates the badge for exposure and then provides the dental office with an exposure report for each radiographer.

Protection for the Environment:

1. The surrounding environment must be protected from radiation to avoid exposure to other persons.
2. Patient should be positioned such that the X-ray beam is aimed at the wall of the room and not through a door or other opening where people may be located.
3. Walls made of 3” of concrete, 3” × 16” of steel or 1 mm of lead will suffice to protect adjacent rooms.
4. As an alternative to lead, Barium can be used in the form of Barium Plaster or Barium Concrete. If it is not possible to incorporate lead or barium into the walls, they can be lined with lead plywood, 0.25 mm of lead sandwiched between layers of wood. If it is not possible to incorporate lead or barium into the walls, they can be lined with lead plywood, 0.25 mm of lead sandwiched between layers of wood.
5. Warning /informative signals to indicate hazardous X-radiation and the patient should be seated away from X-ray room and not allowed to wait in corridors next to X-ray rooms.

Key Points

- Main sources of radiation are from natural and artificial background radiation.
- Protect patients, office staff, clinicians, other healthcare workers and public from unwanted radiation.
- Use clinical judgment for radiographic exposures.
- All exposures should be kept as low as reasonably achievable (ALARA).
- Use only well maintained X-ray equipment.
- If possible, use the machine, which can limit the field of radiation.
- No one should be in the line of primary radiation.
- Use appropriate radiographic techniques.
- Use rectangular collimator instead of round collimator.
- Use proper filtration and collimation.
- Use fastest films available in the market.
- Avoid retakes of radiographs as far as possible.
- Handle the films carefully before and after exposure.
- Do not hold the film, while exposing.