Design of a Protective Barrier in X-Ray Installations

Sixth Lecture (6)

First semester / Second year

By

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Design of a Protective Barrier:

For the purpose of designing protective barriers, one must first know the sources of X-Ray espouse and the types of radiation that can be effective.

Sources of X-Ray Exposure:

There are three types of radiation must be considered in designing the protective barriers of an X-Ray room (See figure 1):

1. The Useful Beam (Primary Radiation)
2. Leakage Radiation
3. Scatter Radiation.

Primary Radiation:

Primary Radiation: (or direct beam) is the most useful beam, and it is the most intense, therefore the most hazardous, and the most difficult to protect against. Therefore, it should avoid exposing anyone other than the patient to the direct beam.

Secondary Radiation:

There are two types of secondary radiation that also require protection: **Scatter Radiation and Leakage Radiation** from the X-Ray tube housing.

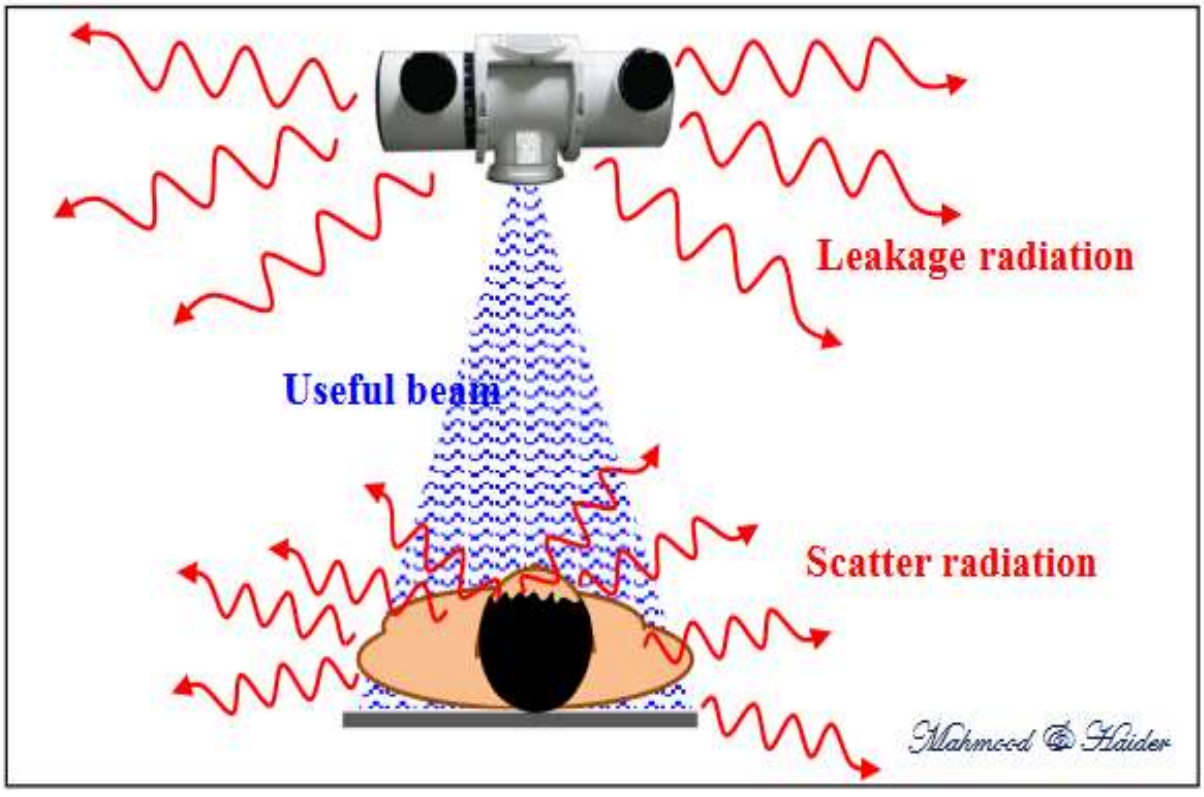

Figure (1): Three types of radiation: the useful beam, leakage radiation, and scatter radiation.

1. Scattered Radiation:

Scattered Radiation: is the radiation that bounces off of matter and air. X-Rays are scattered in all directions when the useful beam strikes any object, including the patient, who is therefore a source of scattered rays.

NOW, how can the staff be protected from Scattered Radiation?

The radiologist and radiographer should be as far away from the patient as is practicable for any given procedure (See figure 2). Lead-rubber aprons and curtains, glass screens, etc., should be used to protect staff from scatter.

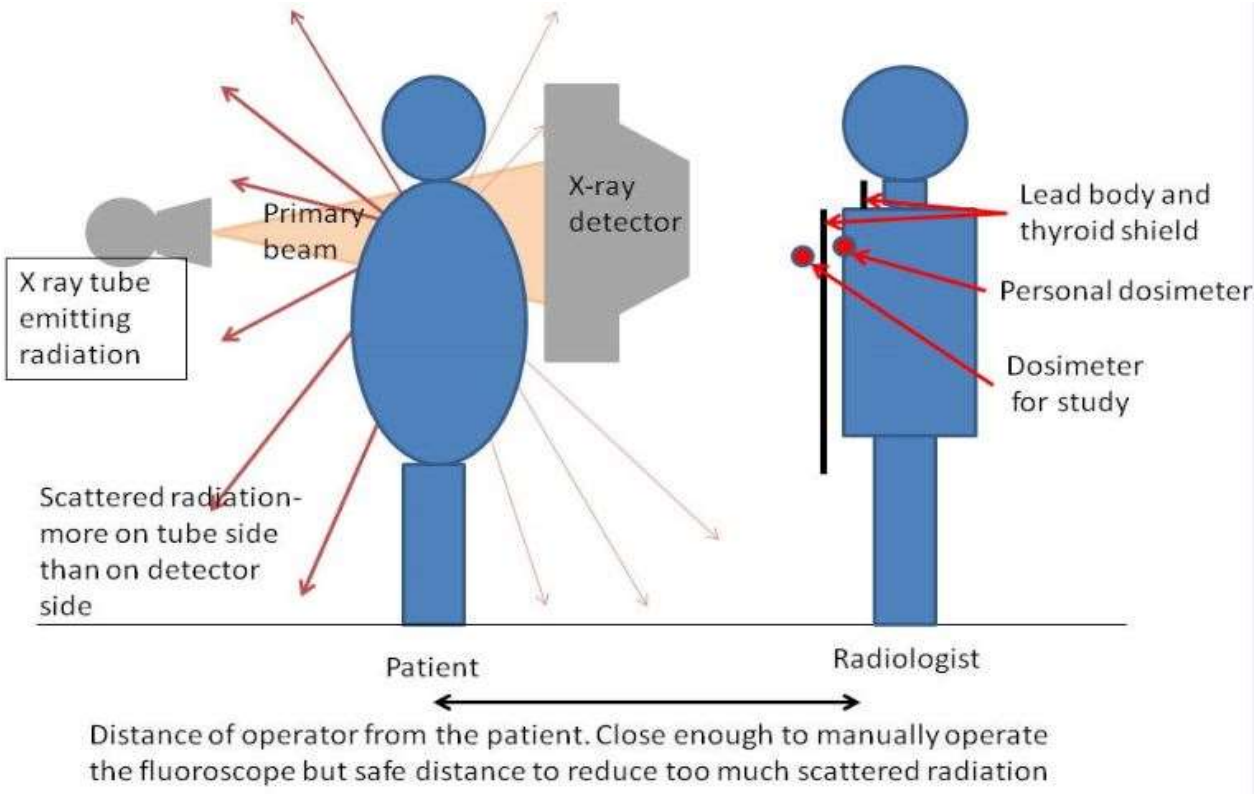

Figure (2): The useful radiation beam and scatter radiation.

*Question: What is the effect of the Scattered Radiation in X-Ray Units?

Answer: With CT scanners, scatter is high close to the aperture, and this area should be avoided when injecting the patient with contrast medium during exposure. During both radiography and fluoroscopy, the patient is the single most important scattering object. **As a general rule, the intensity of scatter radiation 1 m from the patient is 0.1% of the intensity of the useful beam at the patient.**

2. Leakage Radiation:

Leakage Radiation: It is the radiation emitted from the X-Ray tube housing assembly in all directions other than that of the useful beam. When the tube housing is designed properly, the radiation leakage will never exceed **100 mR/hr at 1 meter.** Although, in practice, leakage radiation levels are much lower than this limit.

Protection of Staff and Members of the Public:

The legislation is enacted to ensure that individual doses are low. This is achieved by ensuring premises and practices are by: **Designing a Protective Barriers.**

Design of Protective Barriers:

It is necessary to insert protective barriers, such as sheets of lead, in the walls of X-Ray examining rooms. If the radiology facility is located on an upper floor, then it is necessary to shield the floor as well. A great number of factors should be considered in designing a protective barrier. Any time new X-Ray facilities are being designed or old ones renovated, a medical physicist must be consulted for assistance in designing proper radiation shielding, as has been mentioned before.

Types of Radiation Barriers:

There are two types of radiation barriers, as shown in figure 3: **Primary Protective Barriers and Secondary Protective Barriers.**

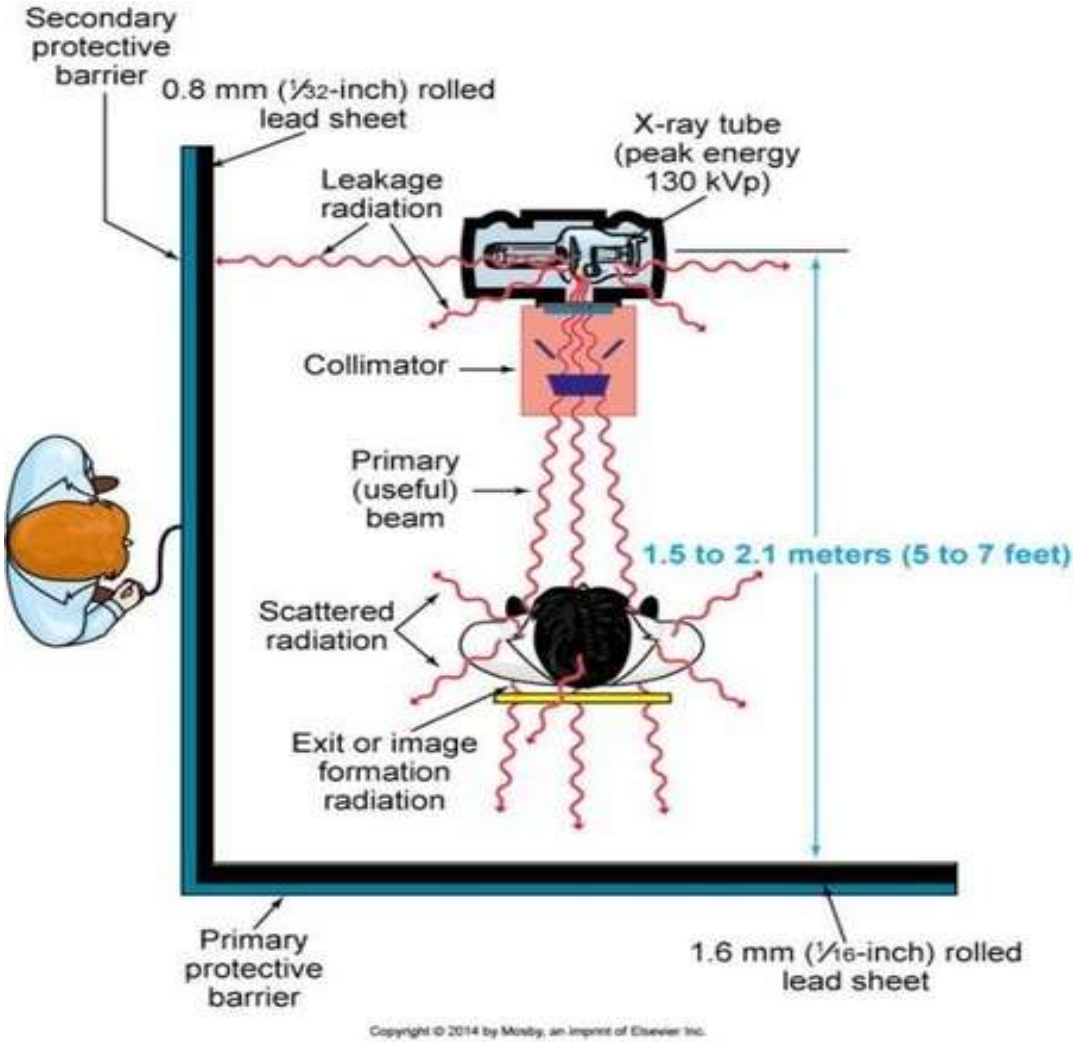

Figure (3): Shows the types of protective barriers.

1. Primary Protective Barriers:

Primary Protective Barriers: are any walls toward which the primary beam may be directed. It is designed to prevent primary radiation from reaching personnel or other people on the other side of the barrier.

2. Secondary Protective Barriers:

Secondary Protective Barriers: are barriers designed to protect areas from secondary radiation and are always thinner than the initial protective barriers. They are designed to protect areas from secondary radiation, including scatter and leakage radiation.

Lead is rarely required for secondary barriers because the computation usually results in less than 0.4 mm of Pb. Table (1) contains equivalent thicknesses for secondary barrier material.

Table (1): The equivalent material thicknesses for secondary barriers.

Computed Lead Required (mm)	Substitutes			
	Steel (mm)	Glass (mm)	Gypsum (mm)	Wood (mm)
0.1	0.5	1.2	2.8	19
0.2	1.2	2.5	5.9	33
0.3	1.8	3.7	8.8	44
0.4	1.5	4.8	12	53

*Question: How is the thickness of protective barriers calculated?

To calculate the thickness of protective barriers, designers must consider four factors: Distance, Occupancy, Workload, and Use factor.

1. **Distance:** An X-Ray machine is best positioned in the center of a room.
2. **Occupancy factor:** A factor used to modify the shielding requirements for a particular barrier by accounting for the percentage of time that the space beyond the barrier is occupied.
3. **Workload:** The radiation-output weighted time when an X-Ray generator is actually delivering radiation; specified either in units of mA seconds per week or mA minutes per week; it is essentially the radiation output when the unit is actually delivering radiation. The average mAs of the X-Ray generator and the number of X-Ray examinations per week.
4. **Use factor:** the fractional amount of time during which the X-Ray beam is energized or directed toward a particular barrier. Also called the beam-direction factor.