Al-Mustaqbal University
Radiological Techniques
Department

Biological Radiation hazards

Ninth lecture

Third Stage

By
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RADIATION DOSE LIMITS

For many years, a maximum permissible dose (MPD) was specified. The MPD was the dose of radiation that would be expected to produce no significant radiation effects.

At radiation doses below the MPD, no responses should occur. At the level of the MPD, the risk is not zero, but it is small lower than the risk associated with other occupations and reasonable in light of the benefits derived. The concept of MPD is now obsolete and has been replaced by dose limits (DLs).

Whole body non-occupational exposure

To establish DLs, the National Council on Radiation Protection and Measurements (NCRP) assessed risk on the basis of data from reports of the National Academy of Sciences (Biologic Effects of Ionizing Radiation [BEIR] Committee) and the National Safety Council. State and federal government agencies routinely adopt these recommended dose limits as law.

Current DLs are prescribed for various organs as well as for the whole body, and for various working conditions.

Particular care is taken to ensure that no radiation worker receives a radiation dose in excess of the DL. The DL is specified only for occupational exposure. It should not be confused with medical x-ray exposure received as a patient. Although patient dose should be kept low, there is no patient DL.

Today, the DL is specified not only for whole-body exposure but also for partial body exposure, organ exposure, and exposure of the general population, again excluding medical exposure as a patient and exposure from natural sources .

Current DLs are based on a linear, nonthreshold dose-response relationship; they are considered to represent an acceptable level of occupational radiation exposure.

Partial-body occupational exposure

Occupational exposure is described as dose equivalent in units of millisievert (millirem). DLs are specified as effective dose (E).

The effective dose (E) concept accounts for different types of radiation because of their varying relative biologic effectiveness. Effective dose also considers the relative radiosensitivity of various tissues and organs.

Wearing a protective apron reduces radiation dose to many tissues and organs to near zero. Therefore, effective dose is much less than that recorded by a collar positioned radiation monitor.

- The value of Wr for other types of radiation depends on the linear energy transfer (LET) of that radiation.
- The tissue weighting factor (Wt) accounts for the relative radiosensitivity of various tissues and organs.Tissues with a higher value of Wt are more radiosensitive.
- The tissue weighting factor ranges from 0.20 for gonads (most radiosensitive) to 0.01 for skin (less radiosensitive)

Dose Limits for Tissues and Organs

- The whole body DL of 50mSv/year is an effective dose which take into account the weighted average of various tissue types and organs.
- Skin some organs have a higher DL than the whole body DL.
  The DL for skin is 500 mSv/year.
- Eyes the DL for eyes is 15mSv/year.

Public Exposure

- Individuals in the general population are limited to 5mSv/year (500 mrem/year) if the exposure is infrequent.
- If the exposure is frequent as with a hospital employee who may visit radiology, the limit is 1 mSv/year (100 mrem/year).
- The 1mSv/year DL is what physicist use to compute thickness of protective barriers.

Educational Considerations

- Student under the age of 18 may not receive more than 1 mSv/year during their course of educational activities. For this reason, student technologists under 18 may be engaged in x-ray imaging but their exposure is limited to 1mSv/year.
- It is a general practice to not accept underage students for RT programs.

X-ray and pregnancy

- Two situations in diagnostic radiology require particular care and action. Both are associated with pregnancy. Their importance is obvious from both a physical and emotional stand point.
- The severity of potential response to radiation in utero is both time and dose related.

Designing for radiation protection

- Leakage radiation emitted by the x-ray tube during exposure must be contained by a protective x-ray tube housing. The limit of leakage must be no more than 1 mGy per hour at a distance of 1 m from the housing.
- The control panel must indicate exposure by kVp and mA meters or visible and audible signals.

- Great attention is given to the design of radiographic rooms, to the placement of x-ray imaging systems, and to the use of adjoining rooms. Two types of protective barriers are used: primary barriers and secondary barriers. Primary barriers intercept the useful x-ray beam and require the greatest amount of lead or concrete.
- Secondary barriers protect personnel from scatter and leakage radiation.

Factors That Affect Barrier Thickness

Many factors must be taken into consideration when the required protective barrier thickness is calculated.

- **Distance.** The thickness of a barrier naturally depends on the distance between the source of radiation and the barrier. The distance is that to the adjacent occupied area, not to the inside of the wall of the x-ray room.
- **Occupancy.** The use of the area that is being protected is of principal importance. If the area were a rarely occupied closet or storeroom, the required shielding would be less than if it were an office or laboratory that was occupied 40 hours per week.
- **Control.** An area that is occupied primarily by radiology personnel and patients is called a controlled area. The design limits for a controlled area are based on the recommended occupational dose limit; therefore, the barrier is required to reduce the exposure to a worker in the area to less than 1 mSv/wk (100 mrem per week).
- **Workload.** The shielding required for an x-ray examination room depends on the level of radiation activity in that room. The greater the number of examinations performed each week, the thicker the shielding that is required.

- **Use Factor.** The percentage of time during which the x-ray beam is on and directed toward a particular protective barrier is called the use factor (U) for that barrier. The NCRP recommends that walls be assigned a use factor of 1/4 and the floor a use factor of 1. Studies have shown these recommendations to be high and therefore very conservative .
- **kVp.** The final consideration in the design of an x-ray protective barrier is the penetrability of the x-ray beam. For protective barrier calculations, kVp is used as the measure of penetrability. Most modern x-ray imaging systems are designed to operate at up to 150 kVp. Most examinations, however, are conducted at an average of 75 kVp.