Assessment of Radiation Shielding in X-ray Room of Medipas Hospital in Mongolia

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1. Introduction

Due to the increasing incidence of cancer in our country, X-ray, tomography, mammography and angiography devices are widely used for diagnosis and treatment. Due to the Covid situation, hospital workloads have increased dramatically, and radiation risk assessments are needed to prevent additional exposure to patients, radiologists and the public. That's why Medipas set out to do a medical radiation protection assessment. This hospital has never had quality assurance measurements. This hospital has never conducted quality assurance measurements. The Objective of radiation shielding in diagnostic x-ray facilities is to protect the workers, members of the public and persons working adjacent to or near the X-ray facility.

2. Theory

A characteristic feature of X-ray shielding designs is that the radiation source has a continuous spectrum, so in theory, simple attenuation like gamma rays. In practice, an experimental damping curve is used to determine the required thickness of protection. NCRP Report No. 147 uses a simple defense calculation like in IAEA Safety Report Series No. 47. When calculating the protection rating of X-ray equipment, the following nomenclature is used:

a. Beneficial rays emitted by radiation tubes for tube radiation: X-(window) X- (primary ray). The rays of the sun are called primary rays.

b. Radiation loss through the radiation tube: X- X- X, (useful radiation) except secondary beam

c. Scattered radiation: X- X refers to scattered radiation

d. Caused by flow radiation (flow radiation): The following factors influence the security requirements of a hospital.

e. Pipe voltage Voltage applied at both ends of the pipe according to the device specifications (pipe potential): X-X-. 400 kV kV. Determine the penetration power of the line. Generally, the unit is used below.

f. Distance: X- The distance from the radiation tube or emitter object to the dose assessment point.

g. Utilization coefficient Depending on the purpose and plan of use, the amount of use of the radiographic apparatus (workload, B): X-mA-min/week. It is usually defined using units.

h. Utilization factor (utilization factor or beam direction coefficient, U) X-1 beam used in the direction of the vehicle barrier. It is the ratio of time to X-rays. The direction of discharge at the rate of use shall be applied as follows:

- The number of people who remained in the enclosure while the residential radiologist was working (operating factor, T): X As a percentage of time, it is determined by the use of space.
- This is the point at which the dose is assessed after the penetration or scattered radiation has passed through the barrier.

i. Point C is the radiation dose that bypasses the protective labyrinth and passes through the gate due to leakage line propagation.

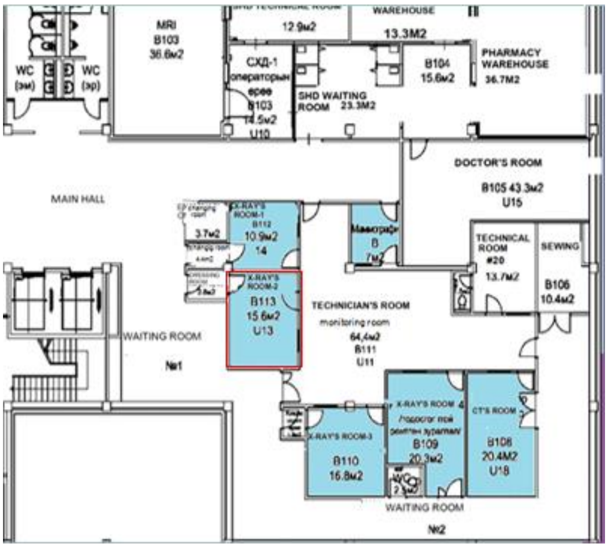
j. Target dose rate. The target dose rate at the dose assessment point behind the barrier, which would be located at that location. It is determined by whether the person who is viewed as a worker is a worker or an ordinary person.

k. Point A (1) is the dose evaluation point behind the barrier (1) in the direction in which the secondary beam is irradiated, and point B is the dose evaluation point after leakage or scattered radiation has passed through the barrier. Point C is the dose of radiation passing through the door by bypassing the shielding maze due to the scattering of the leakage line.

l. Evaluation point. For the barrier against the differential beam, the shielding effect of imaging devices, etc. is also considered. Based on the point where the major organs of a real person can be located.

3. Methods and Results

Apply shielding calculation (P) Target dose rate. In principle, the general design standard dose per week is. It is based on the dose limit determined by A. The effective individual dose limit recommended by A is for occupational exposure. ICRP It is equivalent to 20 mSv per year for exposure and 1 mSv per year for exposure of the general public. The use of X-ray imaging equipment is limited to 50% of workers if an annual week is applied for the conservation of radiation safety. The dose limit in the controlled area is 0.4 mSv/week in the general area and 0.02 mSv/week in the general area.



Picture-1. B1 floor room map of Medipas room

Look at the shape and properties of the radiation source. Thickness of ten layers.
(Half value and tenth value layer) See table calculated using interpolation method
0.88 mm = Lead, 5.3 cm = Concrete
B= (1/10) •n (1)
n = (-ln B)/2.303 • Number of ten layers
t: n × TVL (2)
1. Assess protection in the direction of the floor
The shielding body was installed on the 20 cm thick concrete floor in the performance test room.
width and height 60 cm × 60 cm × 2 mm . is lead plate
P : Maximum exposure dose limit per week 0.02 mSv/week
d :1.2 m Distance from the source to the defensive wall
W : Operating factor 4.2 mA min/week
U : 1 Operation rate
T : 1 Occupancy
B_P (1 X) lane transmittance

$$B_p = \frac{Dd}{WUT} \quad (3)$$
$$= \frac{0.02 \times 1.2^2}{4.2 \times 1 \times 1}$$
$$= 6.86 \times 10^{-3}\ \mathrm{mSv - mA - min}$$

If you calculate the number of ten layers from this value, n=3.16 3.16x6.6 = 20cm.
20cm (TVL:6.6) 2mm (TVL:0.93) as it is shielded with a shield of concrete and lead
Concrete alone satisfies the thickness of the shielding body
2. Examination room 2 lane protection rating
Maximum exposure dose limit per week 0.02 mSv/week
d_s: 0.7 m • Distance from the scattering object to the evaluation point
d_o: 1.0 m • Distance from the focal point to the scattering object
W: • Operating factor 4.2 mA min/week
T: 1 • Occupancy

F: 2,025 cm • Scattering area 2
400: (cm • Standard scattering area 2)
a (1 m, 2) • See table of scattering rates for object area at the distance from the source to the barrier
0.0015 (100 kVp 90°) Conservatively applied scattering angle
B_S: Scattered ray transmittance

$$B_S = \frac{P}{dWT} \times {d_3}^2 \times {d_0}^2 \times \frac{400}{F} \quad (4)$$
$$= \frac{0.02}{0.0015 \times 4.2 \times 1} \times 0.7^2 \times 1.0^2 \times \frac{400}{2025}$$
$$= 3.6 \times 10^{-1}\ mSv/mA - min$$

n=-in3.5E-2/2.303=1.46
If we get the number of ten layers from this value, we get n=1.46 1.46x0.93=1.36 mm
The actual barrier thickness is 5 mm lead. so the thickness of the shield
Leak line evaluation

$$B_{Lx} = \frac{600 \times IP{d_L}^2}{WT} \quad (5)$$
$$= \frac{600 \times 50 \times 0.02 \times 0.7^2}{4.2 \times 1}$$
$$= 70 \times 10^0 mSv/mA - min$$

P : 0.02 mSv/week • Maximum exposure dose limit per week
I : 50 mA • Tube current
d_L : 0.7 m Distance from the focal point to the evaluation point
W : 4.2 mA min/week • Operation factor
T : 1

$$B_S = \frac{P}{dWT} \times {d_S}^2 \times {d_0}^2 \times \frac{400}{F} \quad (6)$$
$$= \frac{0.02}{0.0015 \times 4.2 \times 1} \times 1.1^2 \times 1^2 \times \frac{400}{2025}$$
$$= 0.68\ mSv/mA - min$$

If the number of ten layers is calculated from this value, n<0, shielding against leakage lines is unnecessary.
The actual barrier thickness is 5 mm lead. so the thickness of the shield
3. Security level in the direction of the corridor and control room
P: Maximum exposure dose limit per week
d_s : 1.165 m • Distance from the scattering object to the evaluation point
d_o: 1.0 m • Distance from the focal point to the scattering object
W : 4.2 mA min/week • Operation factor
T : 1 • Occupancy

F : 2,025 cm • Scattering area 2 400 : (cm • Standard scattering area 2)
a (1 m , 3) • See the table of scattering rates for object area at the distance from the source to the barrier: 0.0013 (100 kVp 90°) Conservatively applied scattering angle
B_S : Scattered ray transmittance
The year of payment from this value is 0.88 mm.
The shielding wall is 5 mm.
Leak line evaluation
P• Maximum exposure dose limit per week
I : 50 mA /Tube current/
d_L : 1.165 m Distance from focus to evaluation point
W : 4.2 mA min/week /Operation factor/
T : 1 • Occupancy

$$B_{Lx} = \frac{600 \times IP{d_L}^2}{WT}$$
$$= \frac{600 \times 50 \times 0.02 \times 1.1^2}{4.2 \times 1}$$
$$= 1.93 \times 10^2 mSv/mA - min$$

If the number of ten layers is calculated from this value, n<0, shielding against leakage lines is unnecessary. The actual barrier thickness is 3 mm lead. Therefore, only the thickness of the shield

4. Conclusion

A radiation protection calculation was performed and the results were evaluated to determine if it complies with Mongolian standards.

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