SHIELDING CONSIDERATIONS OF A BUNKER TO BE TAKEN INTO ACCOUNT BY THE REGULATORY BODY FOR AUTHORIZATION PURPOSES: CASE OF RADIOTHERAPY CENTER IN MALI

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1. Introduction

Structural shielding design in a bunker of accelerator's installations aims to limit radiation exposures to members of the public and employees to an acceptable level, i.e. to reduce the effective dose coming from accelerator to a point outside of bunker as low as reasonably achievable. Shielding design is particularly concerned with attenuation of primary beam and secondary radiations in the form of head leakage of accelerator, patient and wall scatter. Thus, finding the optimum barrier thickness is an essential requirement for the safety of facilities. For the building of any bunker able to hold an accelerator for medical or research activities, the owner of facility in collaboration with a qualify expert, medical physicist and architect must establish some detailed plans of the facility with the different thicknesses of bunker (in concrete or lead of primary and secondary barriers) and others areas close to this bunker.

The main objective of this work was to calculate the primary and secondary barrier thicknesses of bunker of the only radiotherapy center in MALI according to the NCRP report 151 methods for authorization purposes. The shielding of main door of bunker was not included in this paper because it was provided with the LINAC by manufacturer.

2. Materials and Methods

2.1. Basic considerations

For any practice related to the using of ionizing radiation, the main objective for shielding in term of radiation protection is to reduce $I_{(out)}$ to the authorized values for public or workers (see figure below).

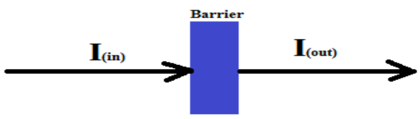

Figure: Basic considerations

$$B_{(x)} = \frac{I_{(out)}}{I_{(in)}} \qquad 2.1$$

$B_{(x)}$ is the barrier transmission factor to determine in order to know the thickness of specified barrier.

2.2. Calculation of $B_{(x)}$ and thickness for primary barriers

The transmission factor of the primary barrier (B_{pri}) that will reduce the radiation field to an acceptable level is given by Equation (2.2).

$$B_{(pri)} = \frac{Pd_{pri}^2}{WUT} \qquad 2.2$$

P is the shielding design goal (expressed as dose equivalent) beyond the barrier and is usually given for a weekly time frame (Sv week^{-1}), $\mathbf{d_{pri}}$ is the distance from the x-ray target to the point protected(meters), **W** is the workload or photon absorbed dose delivered at 1 m from the x-ray target per week (Gy week^{-1}), **U** is the use factor or fraction of the workload that the primary beam is directed at the barrier in question, **T** is the occupancy factor for the protected location or fraction of the workweek that a person is present beyond the barrier.

2.3. Calculation of $B_{(x)}$ and thickness for secondary barriers

i. The barrier transmission for scattered radiation by the patient (B_{ps}) is given by:

$$B_{ps} = \frac{P}{a\,W\,T} d_{sca}^2 d_{sec}^2 \frac{400}{F} \qquad 2.3$$

ii. The barrier transmission for leakage radiation by the head of accelerator (B_L) is given by:

$$B_L = \frac{1000\,P\,d_L^2}{W\,T} \qquad 2.4$$

The thickness of the barrier can then be determined using tenth-value layers (TVL) based on the energy of the accelerator and type of shielding material. The required number (n) of TVLs is given by equation (2.5): $\mathbf{n = -\log(B)}$ 2.5

The primary barrier thickness and the secondary barrier thickness of leakage from the head of LINAC (6 MV) are given by equation (2.6).

$$t_{(barrier)} = TVL_1 + (n-1)TVL_e \qquad 2.6$$

The secondary barrier thickness of scattered radiation from patient and wall is calculated by equation 2.7. $t_{(barrier)} = n \times TVL_s$ 2.7

3. Results

In Mali, the regulated shielding design goals (dose equivalent) for public and workers from practice due to the ionizing radiation are respectively 1 mSv.year^{-1} (which is **2.10^{-5} Sv.week^{-1}**) and 20 mSv.year^{-1} (this dose is optimized to 6 mSv.year^{-1} which is **1.210^{-4} Sv.week^{-1}**). The occupancy factor and the use factor were assumed to be 1 for all adjacent areas. According to the international calculation of radiation protection shielding requirements, a workload of **1000 Gy.week^{-1}** was assumed. The field size of the collimator was **40 x 40 cm^2** at isocenter. The thickness of different barriers was expressed in centimeter of concrete.

The table below was the comparison between the obtained shielding results by AMARAP using NCRP report 151 methods and provided results by architect and qualified expert.

Thicknesses of Barrier in Concrete (cm)			
Location	**AMARAP Results using NCRP 151 Methods**	**Provided Results from experts of "Hôpital du MALI"**	**Obervations**
Primary Barriers			
F	224	235	Good thickness
I	200	235	Good thickness
Ceiling	223	235	Good thickness
Secondary Barriers			
A	110,87	141	Good thickness
B	93,81	60	Thickness should be completed by the shielding maze and door of bunker
C	83,78	60	Thickness should be completed by the shielding maze and door of bunker
D	85,46	117	Good thickness
E	108,73	141	Good thickness
G	113,6	140	Good thickness
H	89,41	141	Good thickness
Ceiling	137,95	141	Good thickness

4. Conclusion

The thicknesses of primary and secondary barriers for LINAC 6 MV Elekta-Compact bunker were calculated using NCRP report 151 by regulatory body (AMARAP) in order to check the provided thicknesses for authorization purposes. The results showed that, the provided thicknesses of different locations were bigger than the ones calculated except location B and C. But in the building plan, there is maze and the thickness of this maze must around **40 cm of concrete.** After building of the bunker, the regulatory controls or inspections revealed that the bunker protects efficiently workers and public around its vicinity against ionizing radiations.