

# SHIELDING EFFICIENCY OF LEAD AND CONCRETE: A COMPARATIVE STUDY

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## BACKGROUND

Lead is the most common shield against x-rays because of its high density, ease of installation and low cost. Though there had been an unguided choice of shielding materials by radiation producers and users particularly in Radiology. There has not been sufficient data and bases for comparing the shielding efficiency of lead and concrete as obtained in various local environments.

## OBJECTIVE

To compare the shielding efficiency of lead and concrete to x-rays of diagnostic energy range (40kVp – 125kVp).

## METHODS

At a fixed FFD of 100cm a uniform x-ray machine setting is used to expose 1.00mm slices of lead using RAD ALERT dosimeter, the HVL of the lead is determined for various KV settings of the machine. This comparison is done with radiation from mobile x-ray unit of kVmax - 100, mASmax - 100 and total filtration 2.5mmAL. This is repeated for different slabs of 15mm thick concrete.

## RESULTS

The results show that the HVL of lead for this energy range 40 - 125kv is 0.55mm - 0.192mm far less than that of concrete 19.6 - 66.3mm at the same energy range. Also the total linear attenuation coefficient of lead is 0.75 - 1.26/mm and 0.010 - 0.035/mm for concrete at this energy range. The total mass attenuation coefficient for lead is 0.66 - 1.12mm<sup>2</sup>/g. This is greater than that of concrete: 0.043 - 0.152mm<sup>2</sup>/g at this energy range.

## INTRODUCTION

The shielding facilities in rooms where ionizing radiation is used or produced is designed in such a way that all possible orientations of the primary beam from the source, persons outside the room or behind the protective screen are not exposed to doses in excess of the recommended levels.

The assessment of dose includes the contributions from primary beam, scattered and leakage radiation. Shields used for primary beam are primary shields while secondary shields are used for scattered and leakage radiation. The factor that must be considered in determining primary shielding material requirement is exposure. This is evaluated using the half value layer measurement or by the product of the distance of the shield from the source, the occupancy factor, the use factor, the workload and the conversion of work load into Rontgens [2].

$$E = \frac{WUT}{d^2}$$

where E is weekly exposure reaching the point in question (R/WK), E is R/mA. Min./wk).

U is the use factor, T is the occupancy factor (no limits) and d is the distance in meters from the x-ray tube to the point in question].

The effectiveness of a shield increases with Density.

Lead is the most common shield against x-rays because of its high density (11340kg/m<sup>3</sup>), ease of installation and low cost [3]. Though there had been an unguided choice of shielding materials (especially for the cubicles and walls of x-ray rooms). There has not been sufficient data and bases for comparing the shielding efficiency of lead and concrete as obtained in our local government. This work is a comparison of the shielding efficiency of lead and concrete to x-rays of diagnostic energy range (40kVp - 125kVp).

Diagnostic application of x-ray contributes more to the radiation exposure to man than any other application [4].

Heavy metals like lead, tungsten, molybdenum with high absorption coefficient for x-rays are used as shields [5].

Shielding can increase the dose rate [6] if the electrons from a high beta source e.g.  $^{32}\text{P}$  strike a lead surface, x-ray photons will be generated. It is best to cover any high z material such as lead or tungsten with a low material such as Aluminum, wood, plastic etc.

Gamma rays that require 1cm of lead to reduce their intensity by 50% will also have their intensity reduced to half by 9cm of packed soil, 6cm of concrete, 2cm of depleted uranium and 150m of air [7].

The implication is that other materials could be used as shield so long as they have sufficient thickness. A high density glass as screen protects television viewers from the effect of the radiation.

#### **MATERIALS AND METHODS**

1. A mobile x-ray machine at the department of radiography Nnamdi Azikiwe University Nnewi campus with the following specifications was used. Kvmax –110, mAsmax – 10, filtration 2.5mmAL.
2. 25 sheets of lead material each 30mmsq and thickness 1.0mm.
3. Slabs of concrete of 15mm thickness.
4. RadAlert 100, Dosimeter. Nuclear radiation monitor
5. Lead sheets of 1mm

The x-ray machine setting for the readings was the same for both the lead and concrete measurements. The FFD is 100cm and mAs was 30. The slabs of concrete and slices of lead sheets were placed erect along the primary beam pathway. The central ray was directed to the center of the shields so as to cover the sensitive area of RADALERT to avoid oblique rays.

The line voltage drop was adequately compensated for before each exposure. Care was taken to avoid air gap between the slabs and slices. Thick concrete slabs were used to absorb oblique rays all around the slices.

The meter measured the energy of the entrance surface beam and the energy of the various exit beams from the inter positions of 1mm slide of lead sheets until the exit energy was exactly half the energy of the entrance surface beam at that kilo voltage setting.

The thickness of lead that produced was noted as the HVL for that kilo voltage. This was repeated for different KV settings for different superimpositions of concrete of 15mm thickness. Steps were taken to avoid error due to parallax on the kV and mAs meters of the x-ray machine.

The HVLs of lead and concrete at kvp of 40-80 were calculated.

The total linear and total mass attenuation coefficients of lead and concrete were calculated using equation (9) and (10) respectively.

#### **RESULTS AND DISCUSSION**

The results obtained from the readings and measurements are presented below (table 2).

In the choice of shielding materials, the energy of the radiation is put into consideration. From the data and the results of the measurements, the half value layer of lead 0.055 – 0.192mm for x-ray of energy 40kV – 80kV, far less than that of concrete 19.6 – 66.3mm at the same energy range. Also the total linear attenuation coefficient of lead 0.75 – 1.26/mm for x-rays of 40kV – 80kV far greater than that of concrete 0.010 – 0.035/mm. The total mass attenuation coefficients of lead 0.66 – 1.12mm<sup>2</sup>/g for x-rays of 40kV – 80kV was found to be greater than that of concrete 0.043 – 0.152mm<sup>2</sup>/g.

**Table 1: Exposure Reduction for Lead and Concrete**

Kvp	CONCRETE		LEAD	
	Thick ness (mm)	Exposure (mR)	Thick ness (mm)	Exposure (mR)
40	0	0.042	0	0.042
	15	0.032	1	0.014
	30	0.017	2	
	45	0.014		
	60	0.011		
45	0	0.082	0	0.082
	15	0.044	1	0.014
	30	0.016	2	
	45	0.010		
	60			
50	0	1.624	0	1.642
	15	1.004	1	0.022
	30	0.303	2	0.020
	45	0.095	3	0.017
	60	0.044	4	
	75	0.017		
55	0	2.306	0	2.306
	15	1.277	1	0.034
	30	0.612	2	0.032
	45	0.158	3	0.031
	60	0.070	4	
	75	0.017		
60	0	2.403	0	2.403
	15	0.947	1	0.046
	30	0.749	2	0.047
	45	0.644	3	0.047
	60	0.272	4	
	75	0.151		
65	0	2.575	0	2.575
	15	2.091	1	0.104
	30	1.514	2	0.099
	45	0.973	3	0.065
	60	0.628	4	0.111
	75	0.273	5	0.040
70	0	2.806	0	2.806
	15	2.149	1	0.236
	30	1.613	2	0.196
	45	1.233	3	0.122

**Table 2: HVLs of lead and concrete**

Energy (kvp)	Exposure (mR)	Half value (mR)	HVL (mm)	
			Concrete	Lead
40	0.042	0.021	19.6	0.55
45	0.082	0.041	21.0	0.60
50	1.624	0.812	23.0	0.65
55	2.306	1.153	24.0	0.70
60	2.403	1.201	26.2	0.79
65	2.575	1.287	38.9	0.74
70	2.806	1.403	39.3	0.81
75	2.849	1.424	44.9	0.86
80	2.861	1.430	66.3	0.92

**Table 3: Total linear and mass attenuation**

Energy (kvp)	m/(mm)		m/p (mm <sup>2</sup> /g)	
	Concrete	Lead	Concrete	Lead
40	0.035	1.261	0.152	1.12
45	0.033	1.16	0.143	1.03
50	0.030	1.07	0.130	0.95
55	0.029	1.00	0.126	0.89
60	0.026	0.99	0.113	0.88
65	0.018	0.93	0.078	0.82
70	0.018	0.85	0.078	0.75
75	0.015	0.81	0.065	0.72
80	0.010	0.75	0.043	0.66

## **CONCLUSION**

The data collected and results of the measurements show that lead is a more efficient radiation shield than concrete within the x-ray diagnostic energy range.

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