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**LEAD EQUIVALENT THICKNESS MEASUREMENT FOR MIXED COMPOSITIONS OF BARIUM PLASTER BLOCK**



**Norriza Mohd Isa**

M. J. M. Isa, N. S. Zainuddin, M. K. M. Zin, S. A. Azizan

Medical Physics,  
KMS, BKS  
DTI, Sesi 6A

## Outline

- Introduction
- Objectives
- Materials & Methods
- Result & Discussion
- Conclusion
- References

## Introduction

- Measurement of lead equivalent thickness for ionizing radiation exposure room wall shall be performed as stated in Malaysian Standard MS 838 (2007) & MS 2228(2009).
- Purpose of shielding : To limit radiation exposure to employees and members of the public to an acceptable level.
- The Malaysian Ministry of Health (MOH) has established that the irradiation room must have sufficient shielding thickness

## Gamma radiation shielding

- Most materials absorb the energy of gamma rays to some extent.
- The extent of attenuation depends on:- the density of elements, thickness of the shielding material ,the mass per unit area of shielding material & energy of the incident gamma radiation, the atomic number and also activity of radionuclide.
- Hence a thick layer of a lighter material will have the same effect as a thin layer of a denser material.

## The attenuation of gamma shielding:-

$$I = I_0 e^{-\mu \rho t} \quad \text{or} \quad I = I_0 e^{-\mu d}$$

$I$  = intensity after shielding  
 $I_0$  = incident intensity  
 $\mu$  = mass absorption coefficient ( $\text{cm}^2/\text{g}$ )  
 $d$  = thickness of absorber ( $\text{g}/\text{cm}^2$ )  
 $\rho$  = density of absorber ( $\text{g}/\text{cm}^3$ )  
 $t$  = physical thickness of absorber (cm)

## Interaction Gamma with Matter:-

- Photoelectric Effect (high Z, , 50 keV)
- Compton Scattering (low Z, 100 keV – 10 MeV)
- Pair Production (low Z, 1.02 MeV)

### Shielding Design Materials

- ✓ Interior Wall-Gypsum wall board, lead sheet, steel nail, screw, concrete block, clay brick and etc.
- ✓ Some of them has voids –can be filled with grout, sand or mortar
- ✓ Exterior Wall-Stone, brick, concrete, wood, vinyl and etc
- ✓ Lead lined door or wooden door (calcium silicate)
- ✓ Floor or ceiling – metal-deck-supported Concrete (typical thickness : 4 -20 cm)-standard weight/light weight .
- ✓ The distance (floor & ceiling) - at least 2.1m

Composite materials are becoming increasingly available from shielding manufacturers.

UHPC –Ultra High Performance Concrete

### Shielding verification activity for exp. rooms

### Objective

To determine the lead equivalent thickness (LET) of samples using Cs-137, Am-241 & Co-60

### Materials

- Radioactive Source
- Survey meter ( 451P-RYR, S/N: 2469)
- Lead (Pb) sheets
- Measuring tape
- Adjustable source holder with container
- PPE

### Material-radioactive sources

Source	Half life	Energy (keV)	S/N:	Initial Activity	Date	Activity during measurement
Cs-137	30 yrs	662	1618-35	996 uCi	1 Jun 2013	946 uCi
Am-241	432 yrs	59	5218 lv	200 mCi	N/A	26.5 mCi
Co-60	5.3 yrs	1332 1170	1639-67-3	106.7 uCi	1 Jun 2013	73 uCi

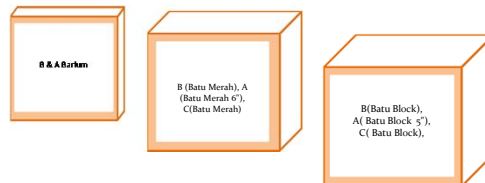
### Measurement of sources activity

## samples

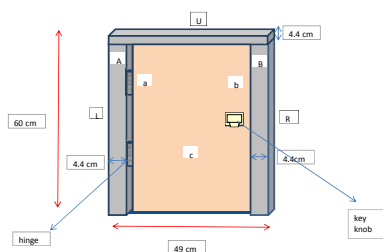
- ❖ 9 samples (barium plaster) from a company to be tested



## Sample Blocks:-



## Door and Frame:-



## B & A Barium :-

- 3cm thickness including back frame
- 0.5 cm thickness of back frame
- 2.5 cm thickness of Barium only
- Surrounding frame thickness is 1.5 cm
- Length x Width of Barium only = 30.5 x 30.5 cm
- Length x Width of Barium including frame = 33.5 x 33.5 cm

## B (Batu Merah), A (Batu Merah 6"), C (Batu Merah):-

- 0.5 cm back frame thickness
- 15 cm thickness of concrete
- Surrounding frame adalah 1.5 cm tebal not including back frame
- Length x Width of compositions = 33.5 x 33.5 cm

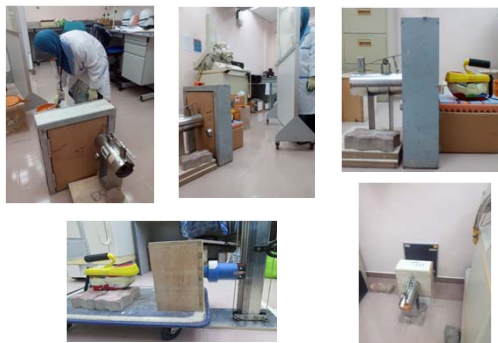
## B (Batu Block), A (Batu Block 5"), C (Batu Block):-

- 0.5 cm back frame thickness
- 12.6 cm thickness compositions
- Surrounding frame adalah 1.5 cm tebal not including back frame
- Length x Width of compositions = 33.5 x 33.5 cm

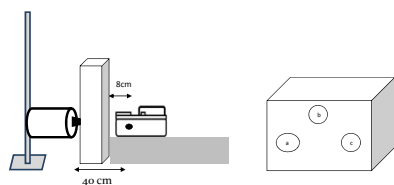
## Method

- Build up calibration curve for 3 sources using Pb sheets at SID ~ 40 cm
- Open window size of source casing: various diameter
- Test the samples using the 3 sources
- Analyzed the data obtained
- Determine the lead equivalent thickness using Matlab software based on calibration curve

## Experiment Set-up

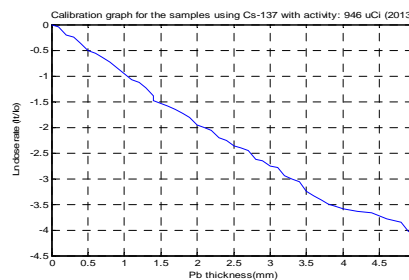


## Schematic Diagram of experiment set up

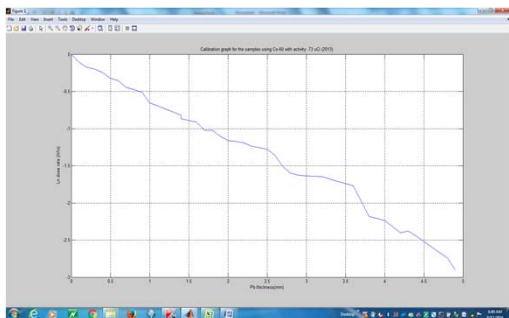


## Result & Discussion

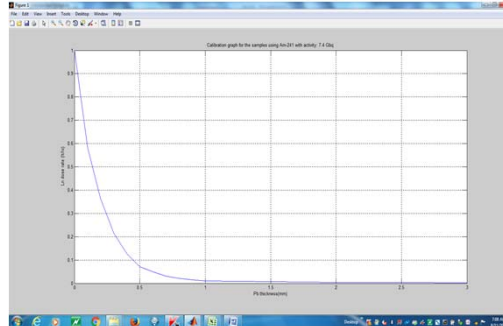
Calibration Graph for Cs-137

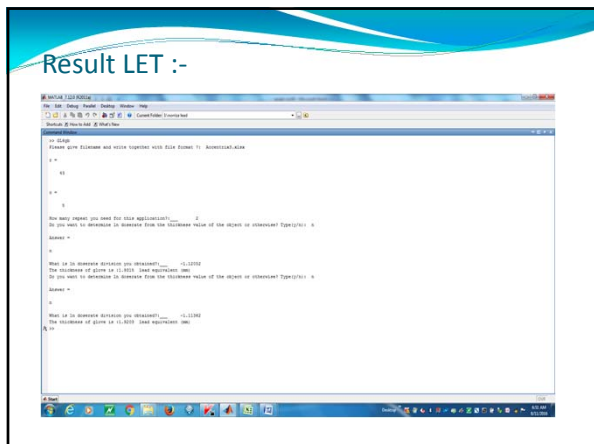


## Calibration graph for Co-60:-



## Calibration Graph for Am-241:-



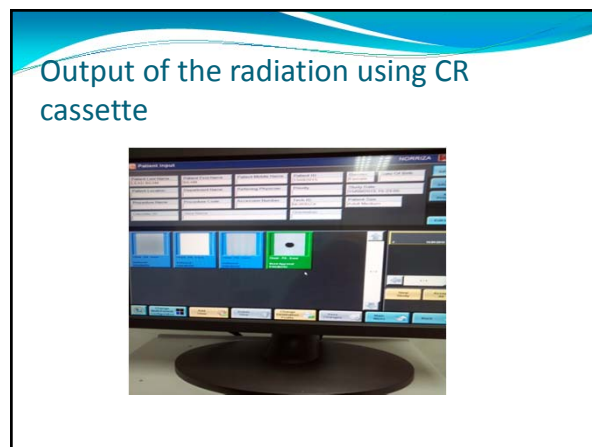


### LET for Blocks:-

Physical Thickness (cm)	Radioactive Source	Cs-137	Am-241	Co-60
	Samples	Average Lead Equivalent Thickness, T (mmPb)	Average Lead Equivalent Thickness, T (mmPb)	Average Lead Equivalent Thickness, T (mmPb)
15.0	A (Batu Merah 6")	1.374	>> 2mmPb	1.9315
15.0	B (Batu Merah)	1.370	>> 2mmPb	1.9203
15.0	C (Batu Merah)	1.313	>> 2mmPb	1.697
12.5	A (Batu Block 5")	0.544	>> 2mmPb	0.6763
12.5	B (Batu Block)	0.764	>> 2mmPb	0.9006
12.5	C (Batu Block)	0.725	>> 2mmPb	0.8035
2.5	A (Barium)	0.357	>> 2mmPb	0.4261
2.5	B (Barium)-3cm tebal	0.384	>> 2mmPb	0.4684

### LET for Door & Frame:-

Radioactive Source	Cs-137	Am-241	Co-60	
Samples	Average LET (mmPb)	Average LET (mmPb)	Average LET (mmPb)	
Door	a	0.153	0.995	0.293
	b	0.281	1.130	0.305
	C	0.315	1.157	0.416
	Key	0.655	2.324	0.695
Door Frame	U	1.499	1.168	1.883
	R	1.839	1.164	1.911
	L	1.891	1.231	2.145



- ### Based on the result:-
- i. Higher physical thickness will give higher LET
  - ii. The same physical thickness is not give same LET
  - iii. The LET for the samples is higher for Co-60 compare to Cs-137. (Reason Even Co-60 has higher energy, it can penetrate more caused of its activity is lower than Cs-237).
  - iv. No Am-241 radiation passed through the samples cause of low energy and low activity except for the door & its frame.
  - v. The LET side a of door is less compare to b side (hinge-give space), therefore more scattered radiation.

- ### Limitation of the test
- Shield Case for the Am-241(cylinder) is different design with Co-60 (vial) & Cs-137 (vial) cause of different container of source.
  - The beam is a broad beam, scattered radiation contribute the extra reading to detector.
  - The width of frame sample is smaller compare to diameter of collimator window.
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## Conclusion

- ❖ The LET of the shielding material is depend on
  - i. Composition of material
  - ii. Energy of source
  - iii. Activity of source
- ❖ Good shielding material should have similar characteristic with Pb.

## Future measurement

- Set-up using various activity of same energy
- Protect detector from scattered radiation
- Geometry set up for verification test always use the same geometry set-up during calibration.

## References

- MS 838:2007, Code of practice for Radiation Protection-Medical X-ray Diagnosis
- J. C. Courtney *et al.*, "Photon shielding for a positron emission tomography suite," *Health Phys.* **81**, S24-28 2001.
- Madsen, Mark, et al. *AAPM Task Group 108: PET/CT Shielding Requirements*. *Medical Physics* 33, 1 (January 2006): 4-15.

## Acknowledgment

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**Thank you for  
your attention**