Monte Carlo Simulation of Radiation Leakage and Design Optimisation for Doorsets of X-Ray Facilities

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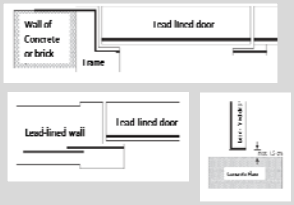
A- Summary

With the aim of doorset shielding optimisation, the results of this study show that:

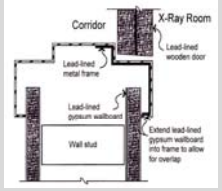
- Radiation leakage may dominate the dose rate behind the door even when the core lead thickness has been correctly specified
- A door mat solution against radiation leakage from the gap between the door and the floor could be effective but may not be desirable from other practical viewpoints
- When performing radiation surveys, due consideration should be given to the possible heterogeneous distribution of the radiation field

B-Design guidelines

WHO 1974



NCRP 147, 2004



C- Material & Methods

(i) Manufacturing considerations*

- Door weight
- Mechanical integrity
- Standards (e.g. Fire resistance)
- Finishing preferences
- Cost:
  - Materials
  - Fabrication
  - Installation
- Durability and maintenance considerations

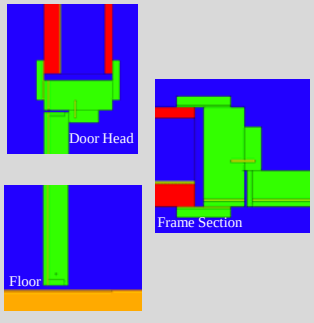
* The information provided by **WARDRAY PREMISE LIMITED** in respect of the manufacturing considerations is gratefully acknowledged

(ii) Monte Carlo simulations

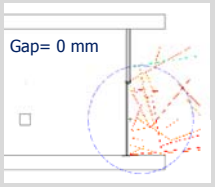
- 90kVp X-rays, incident on a water phantom (30x30x30cm^3) placed at the centre of the examination room
- MCNPX version 2.5.0
  - Photon Flux Mesh Tally
  - Particle Flux Tally – dose function modified
  - Cut-off energy 10keV
  - Relative errors < 5% (1.s.d.)

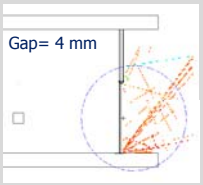
(iii) Doorset design

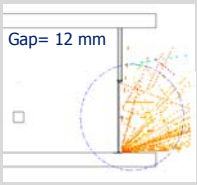
- Hardwood
- Lead 2.24 mm (Code 5)
- Fixture and fittings
  - Expanding smoke seals
- Lead lined Gypsum wall



D- Results 1- Leakage through the door & floor gap

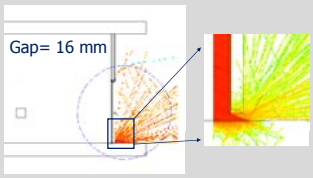


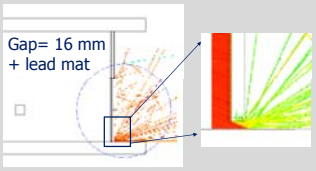




The lead mat solution:

Leading to reduced dose rate by ≥ 350%

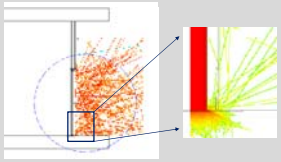




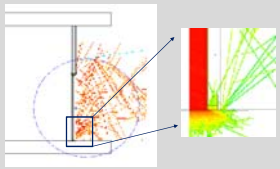
E- Results 2- Optimisation of shielding design

(i) floor level detail (without lead mat)

Un-optimised shielding design



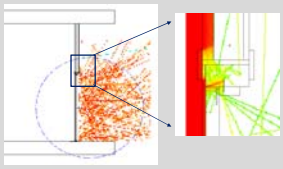
Optimised shielding design:
additional lead incorporated in the door and frame



Leading to improvement in dose rate of ≥ 30%

(ii) Head level detail

Un-optimised shielding design



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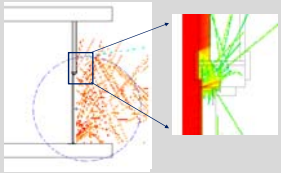
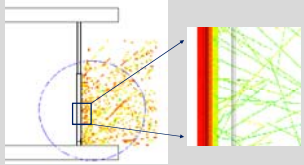


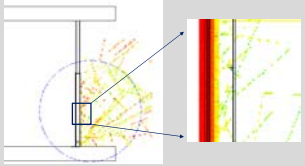
Leading to improvement in dose rate of ≥ 45%

(iii) Centre level detail

Un-optimised shielding design



Optimised shielding design:
additional lead incorporated in the door and frame



Leading to improvement in dose rate of ≥ 45%

(iv) Leakage dose rates behind the shielded door*

	Height of simulation point from the floor		
	50 cm	**100 cm**	**170 cm**
Un-optimised design: without door mat	16	9.2	8.3
Optimised design: without door mat	11	4.8	4.5
Optimised design: with door mat	3.2	3.1	2.6

* *Expressed as the ratio of dose rate behind the shielded door to the dose rate behind the leakage-free barrier 2.24 mm thickness of lead; door to floor gap set at 8 mm*