Specification of Shielding requirements for PET CT facilities

DG Sutton[1], DJ Peet[1], JR Williams[3], CJ Martin[4]

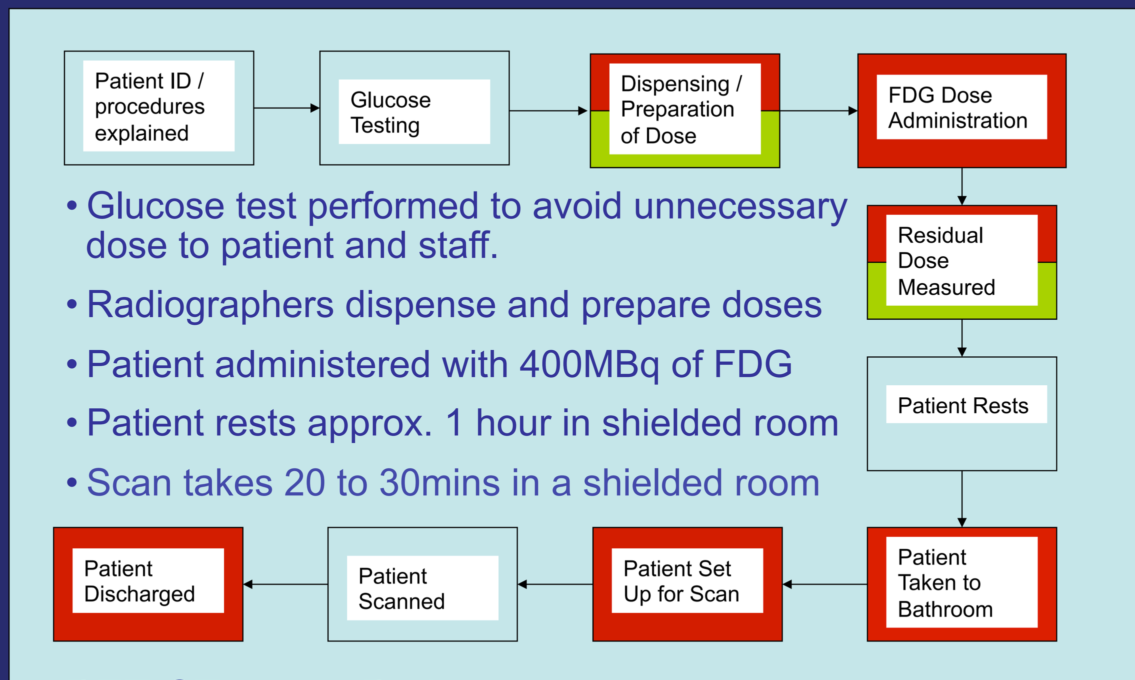
1. Medical Physics, Ninewells Hospital, Dundee, UK
2. Radiation Protection, Royal Surrey County Hospital Guildford, UK
3. Medical Physics, Royal Infirmary of Edinburgh, UK
4. Health Physics, Gartnavel Royal Hospital, Glasgow, UK

Introduction

The BIR report[1] describing methods for assessment of shielding requirements for medical X-ray facilities has been revised to take account of developments in equipment and techniques. PET/CT is being included in the second edition of the book.

The specification of shielding for PETCT facilities should not simply involve the calculation of the shielding requirements in individual barriers, but also requires an understanding of the clinical process so that the rooms are laid out to aid patient flow yet minimise staff and public exposure.

The 511keV gamma ray emitted is more penetrating than the radiation typically seen in the diagnostic environment. The patients remain within the facility through an uptake phase and the scan for up to 2 hours, multiple patients could be in the unit at any one time, and the external dose rate from each patient is higher than that typically seen for other Nuclear Medicine procedures. These factors present a hazard to staff and the public within and immediately around the facility including areas above and below.



PET CT scans Patient process

Design considerations

The flow of the patient needs to be foremost in the design with minimal distance between injection and dose preparation room, hot toilet and the scan room.

Once the relative positions have been set, the use of the inverse square law to maximise the distance between the control room and the rest areas can be most effective in reducing the thickness of shielding required.

Where there is no possibility of placing the rest rooms away from the control room, eliminating any lines of sight from the resting patients to staff positions is important. In the worst cases a mini maze can be constructed around the patient to cut off sight lines or to shield other areas such as the preparation room.

Adjacent areas should where practicable have low occupancy eg external walls and corridors. Offices are likely to be the worst case.

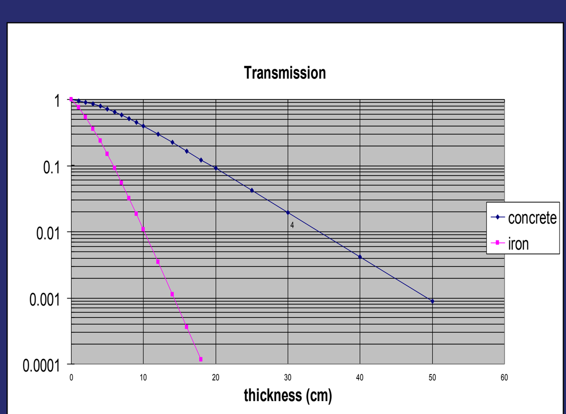
Attenuation by the gantry does occur and thinner barriers in the shadow of the gantry could be incorporated into the design should weight or other issues be a particular concern. However it should be noted that many centres use constant wall thicknesses as the cost of siting the scanner incorrectly could be prohibitive.

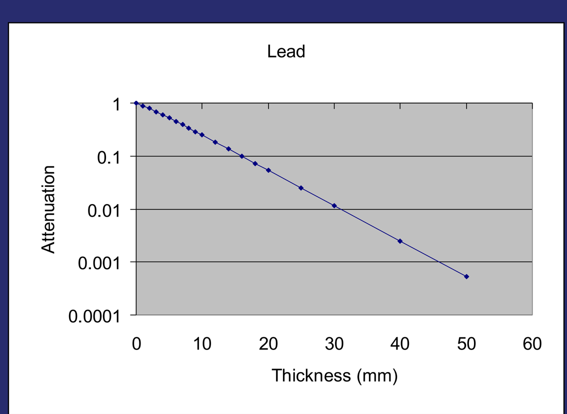
Floors and ceilings must be considered if areas above or below are occupied.

Calculation Parameters

Transmission:

	1st TVL (cm)	Limiting TVL (cm)	1st HVL (cm)	Limiting HVL (cm)
Lead	1.6	1.5	0.5	0.5
Concrete	19	15	8.3	4.5
Iron	5.8	4	2.2	1.2





Dose rates:

The effective dose rate from patients during each phase are as follows:

37μGy h-1 at 1m for the uptake phase

24μGy h-1 at 1m for the scan phase.

These numbers allow for decay during uptake and scanning, patient attenuation, and excretion.

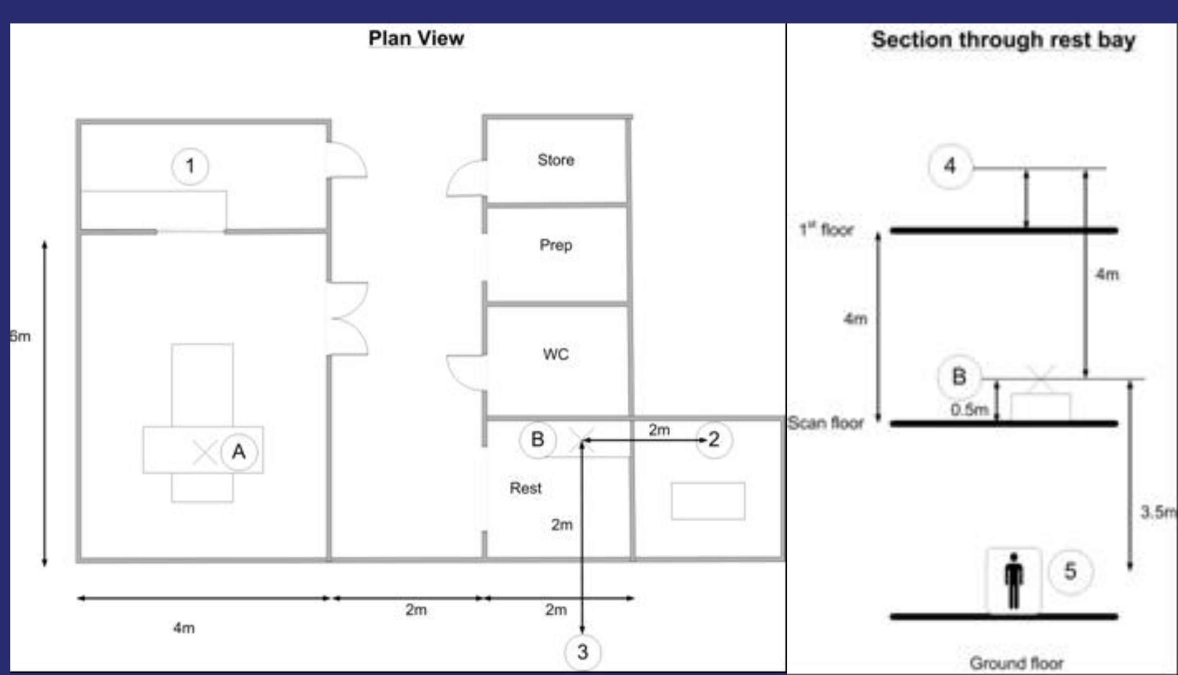
Dose Constraints:

A dose constraint of 0.3mSv should be applied to members of the public.

Occupancy factors can be applied where appropriate to meet this constraint.

A dose constraint of 0.3mSv should also be applied to staff in the control room. However this is not always possible and other constraints of 1 or 2mSv could be used.

Sample Calculation



Consider point 2 in the office adjacent to the uptake bay

Distance from patient in rest room is 2m
Air kerma rate – 37uGy/hr
Correct kerma rate for distance – 9.25uGy/hr
Dose per annum (2000hrs) 18.5mSv
Constraint 0.3mSv
Attenuation factor (AF) / transmission required
0.3/18.5 = 0.02
No of TVL's = log10(1/AF)
1.79 TVL's required – 270mm concrete / 30mm lead

Point of interest	1	1	2	3	4	5
Source	A	B	B	B	B	B
Kerma rate at 1m (μGv h-1)	24	37	37	37	37	37
Distance (m)	4.00	7.20	2.00	2.00	4.00	3.50
IDR uSv/hr at point of interest	1.50	0.71	9.25	9.25	2.31	3.02
Occupancy	100	100	100	10	100	100
Dose per annum at point of interest (mSv per annum)	3.00	1.43	18.50	1.85	4.63	6.04
Attenuation factor required	0.10	0.21	0.02	0.16	0.06	0.05
No of TVLS	1.00	0.68	1.79	0.79	1.19	1.30
Thickness concrete 2350kg/m3 (mm)	150	102	269	119	178	196
Thickness concrete blocks 2000kg/m3 (mm)	176	119	315	139	209	229
Thickness lead (mm)	17	12	30	13	20	22

Additional points to consider:

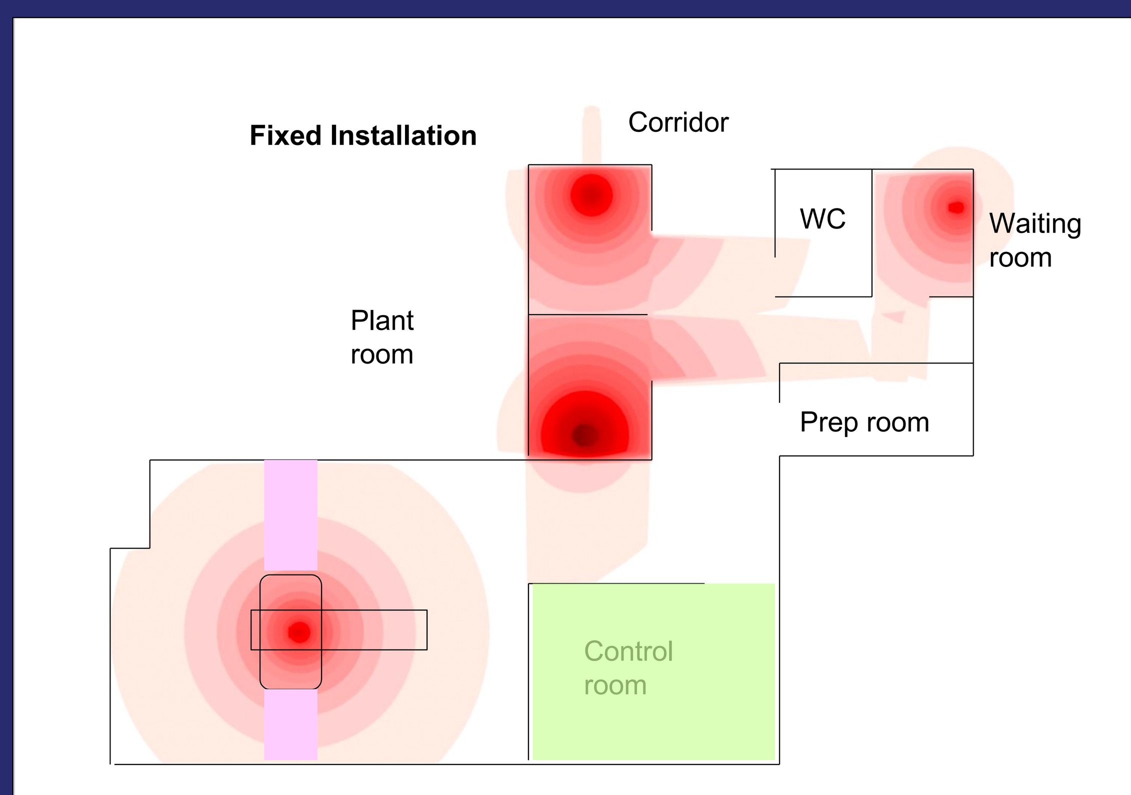
Calculation points may receive dose from more than one source.

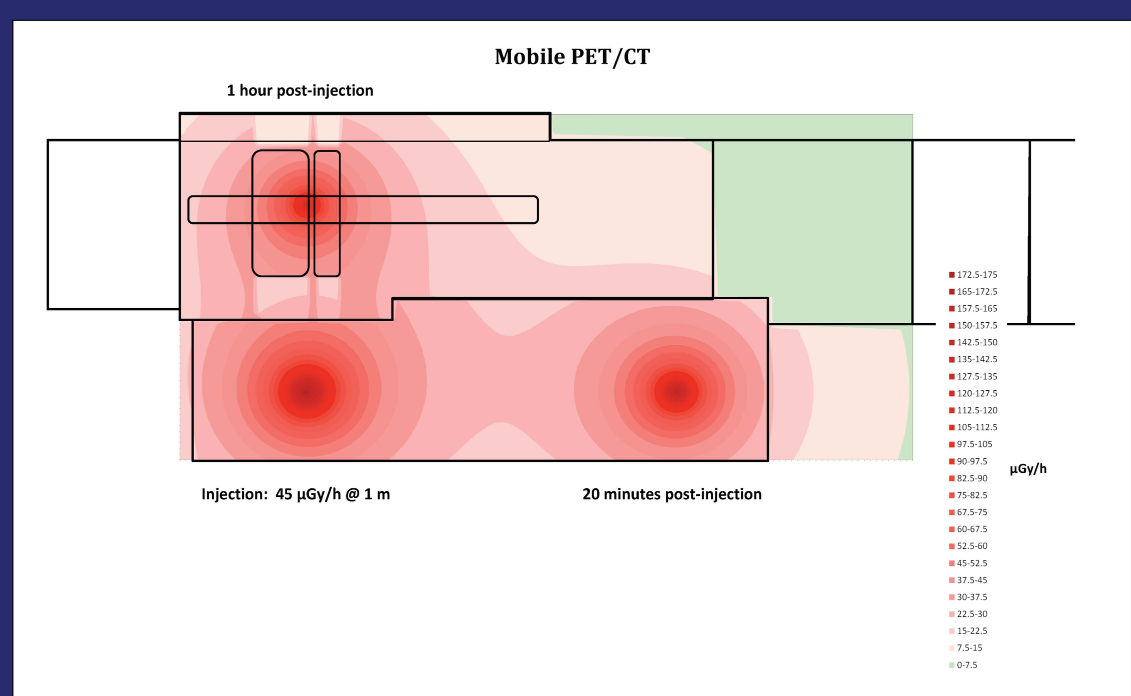
One approach to deal with this is to use a lower constraint form each source to calculate required barrier thickness.

Another is to select barrier thickness and calculate the total dose from all sources.

Operational considerations

Staff receive additional dose within the facility. One way to encourage staff to remain within areas where dose rates are lower is to use pictorial representations of the dose rates as follows:





These plots show the importance of distance and shielding in reducing dose rates. The challenge in the mobile scanner environment is highlighted clearly.

Reference

1: BIR(2000) Radiation shielding for Diagnostic X-rays eds Sutton DG Williams JR BIR London

For more information, please contact
Debbie Peet
Radiation Protection
Royal Surrey County Hospital
Guildford
debbie.peet@nhs.net