CHAPTER 6

PROTECTION FROM EXTERNAL RADIATION

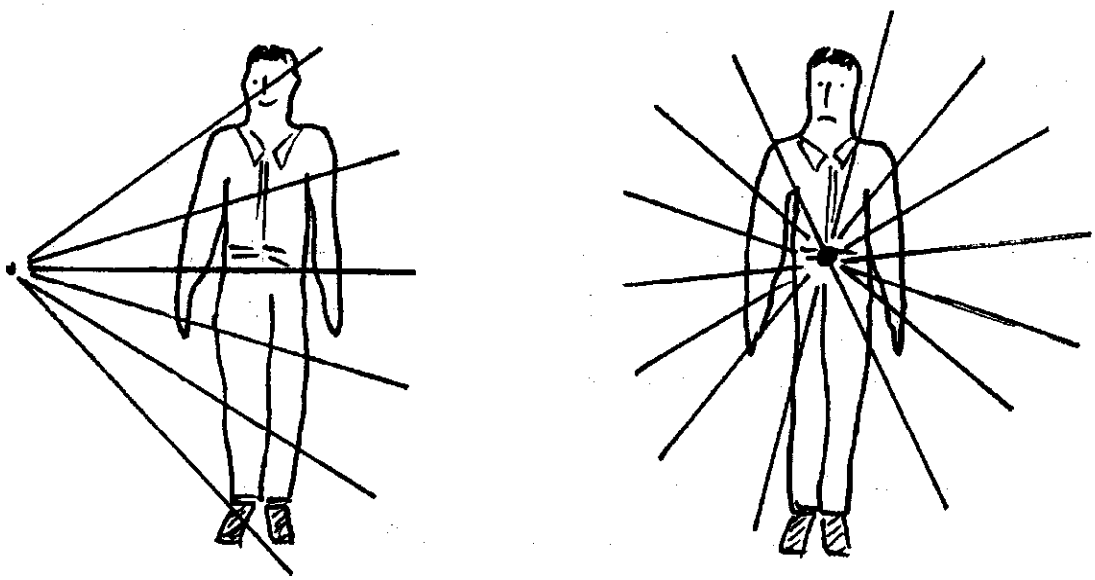


Fig. 6.1. External and Internal Exposure

TIME, DECAY, DISTANCE & SHIELDING

External radiation exposure can be decreased by:

1) reducing the **TIME** spent near a source;

2) allowing the source to **DECAY** before approaching it;

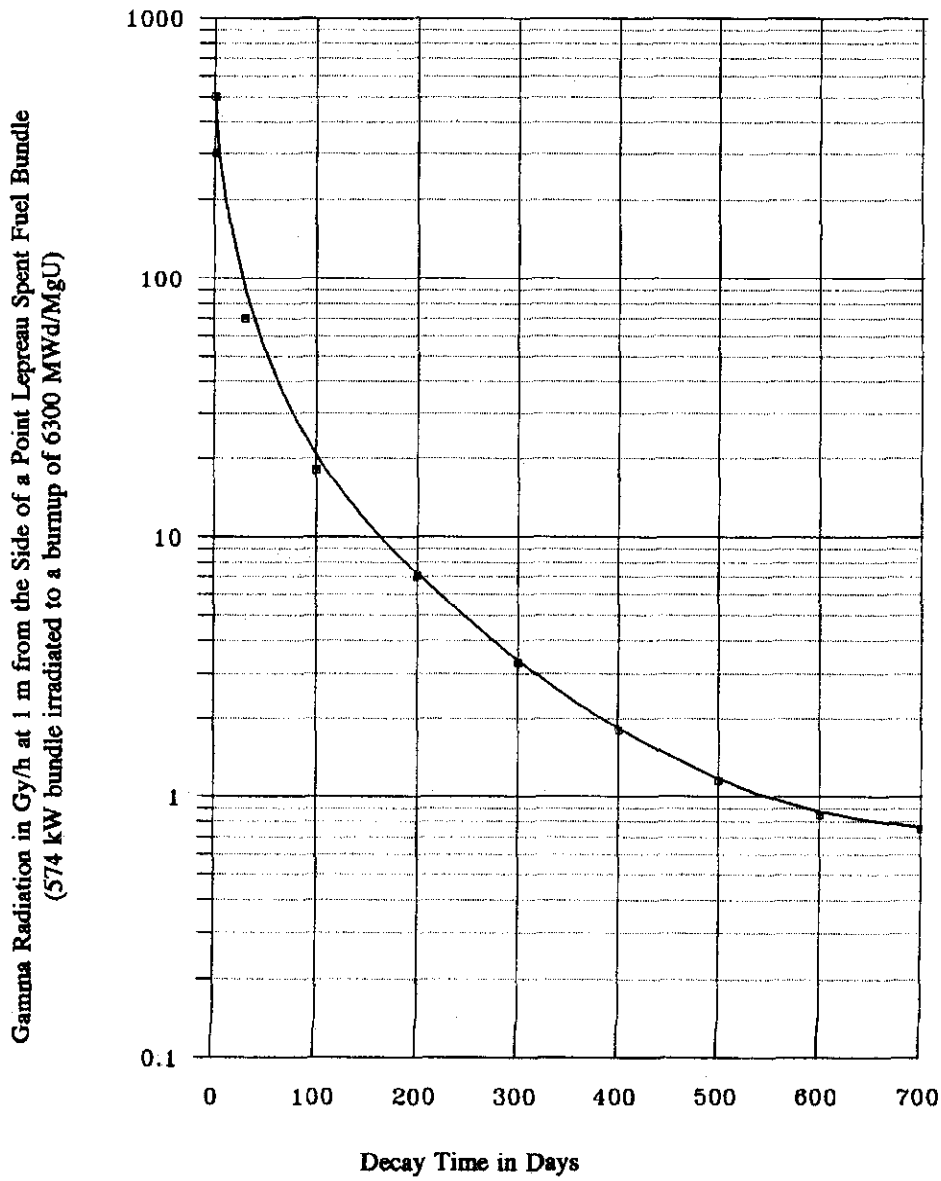
3) increasing the **DISTANCE** between yourself and the source;

4) absorbing the radiation in **SHIELDING** material placed between yourself and the source.

DECAY

$n(t) = n(0) \exp(-\lambda t)$

$\lambda = \ln 2 / t_{1/2}$



Decrease in Fission product Activity with Time.

Radiation Fields drop to about 1% after every 7 half-lives

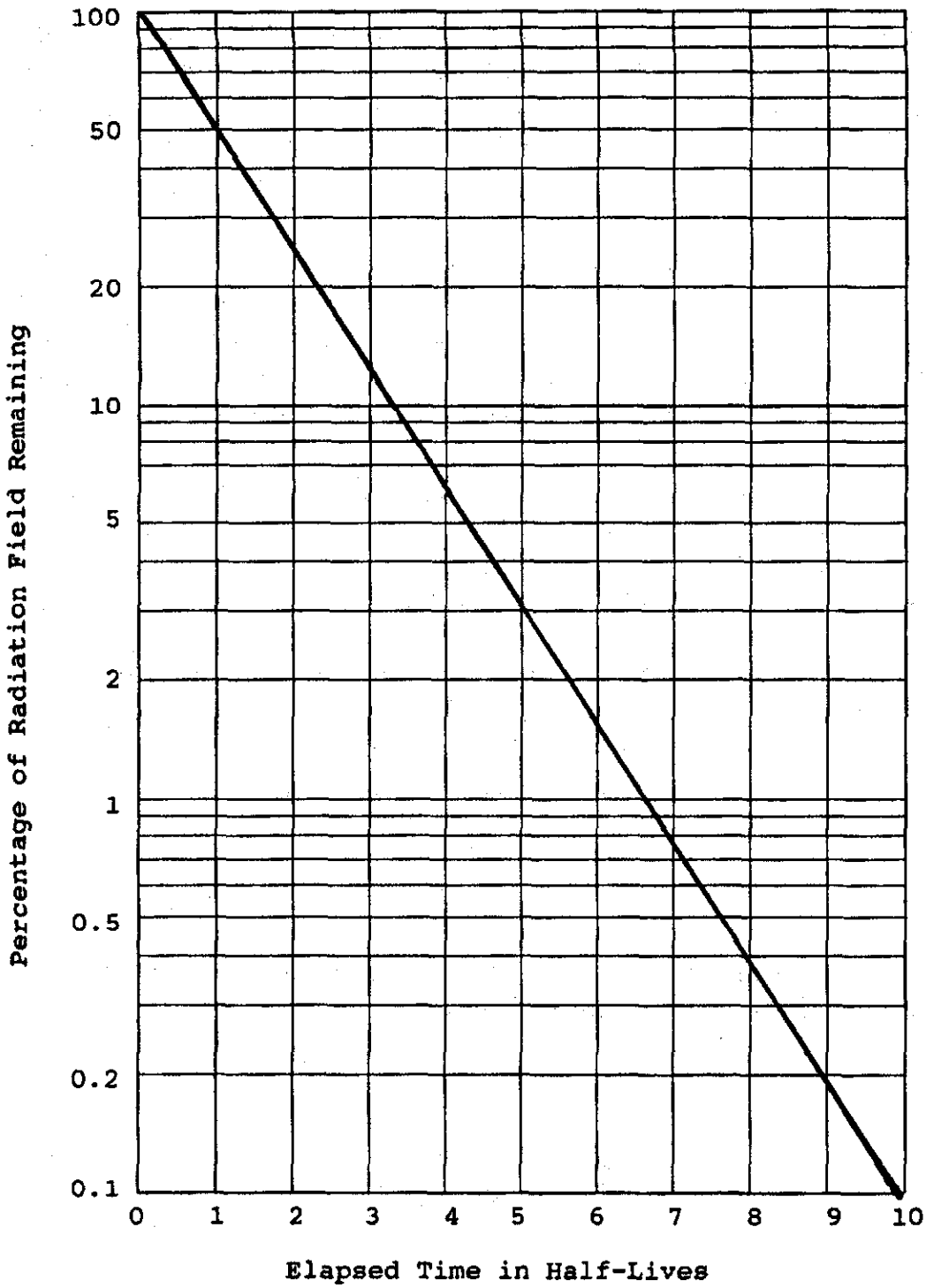


Fig. 6.2. Decrease of Radiation Fields With Time

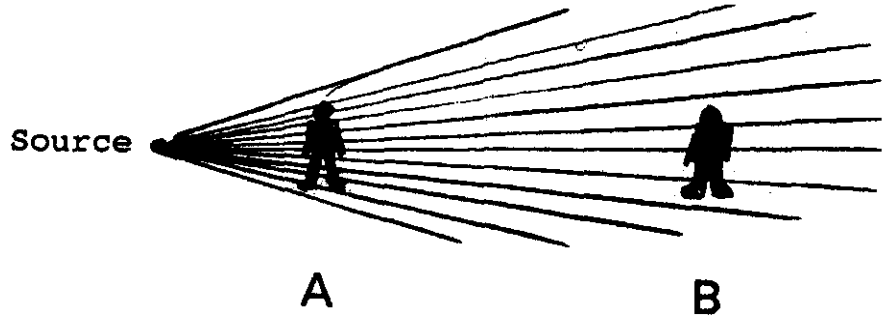
DISTANCE

"point" sources: inverse square law

gamma only

no shielding

no beams



"line" sources: inverse drop off

"plane" sources: little drop off

beta sources

alpha sources

Fig. 6.4. Fraction of Radiation Field Remaining

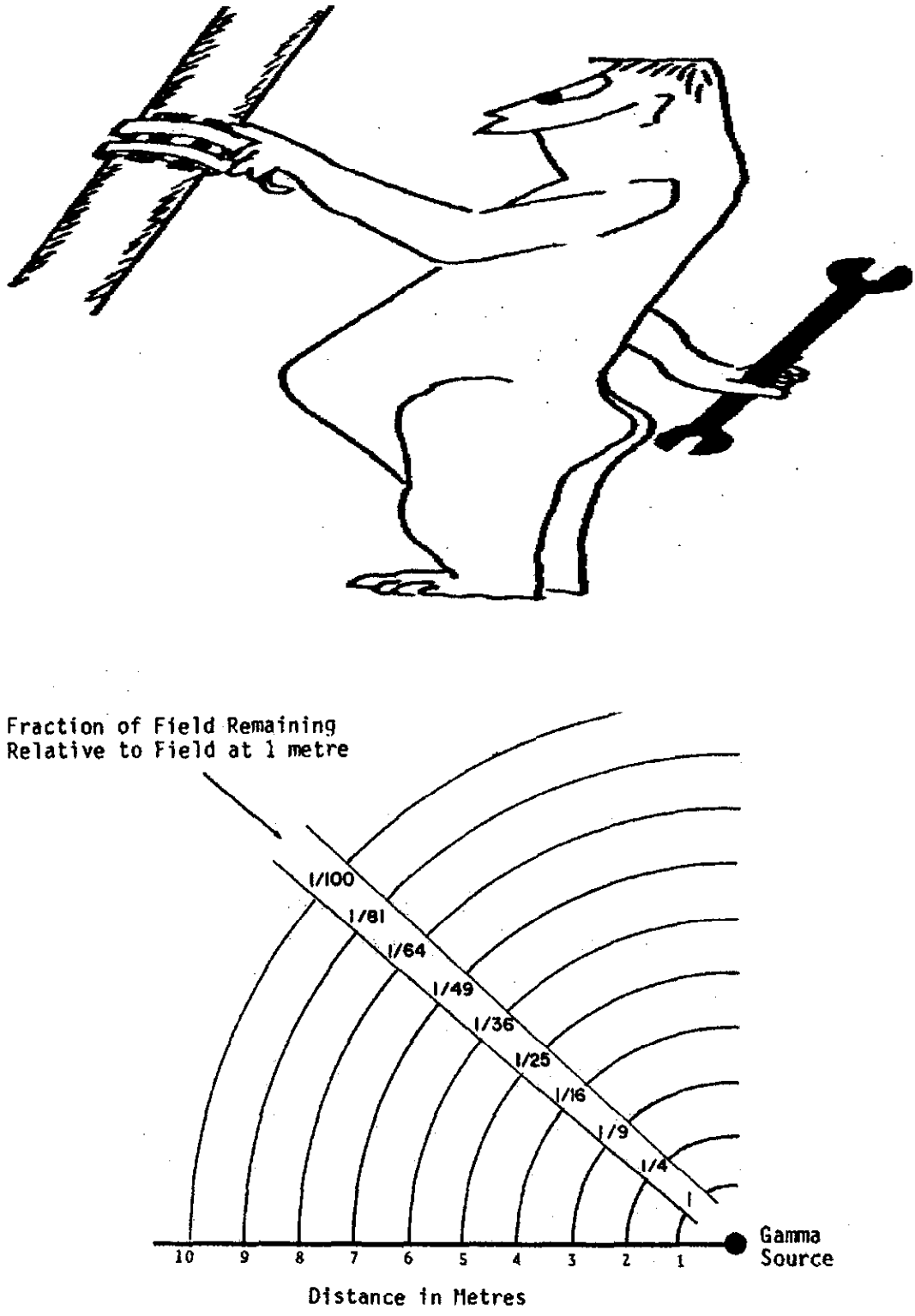


Fig. 6.5. Lepreau Maintenance Supervisor

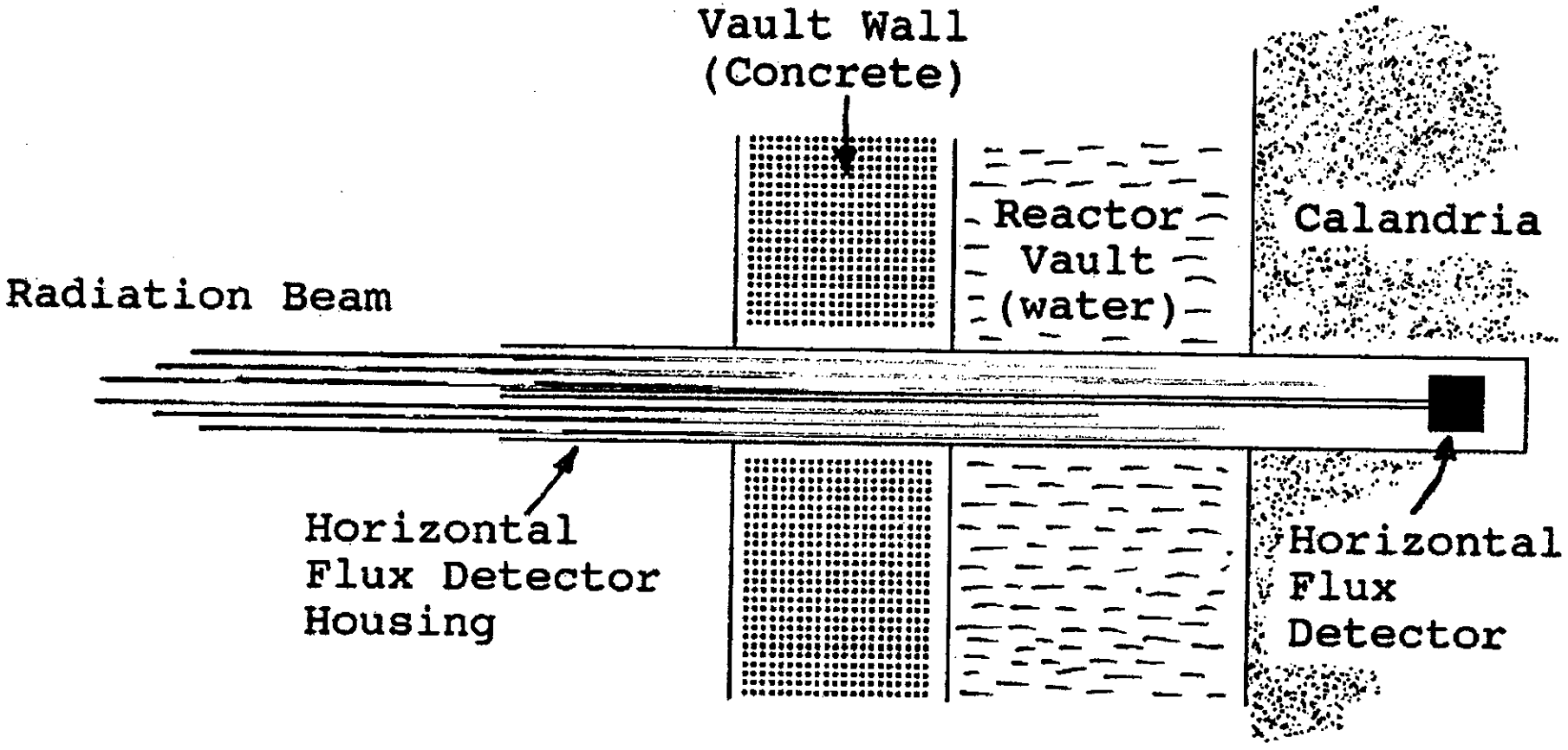


Fig. 6.6. Radiation Beams

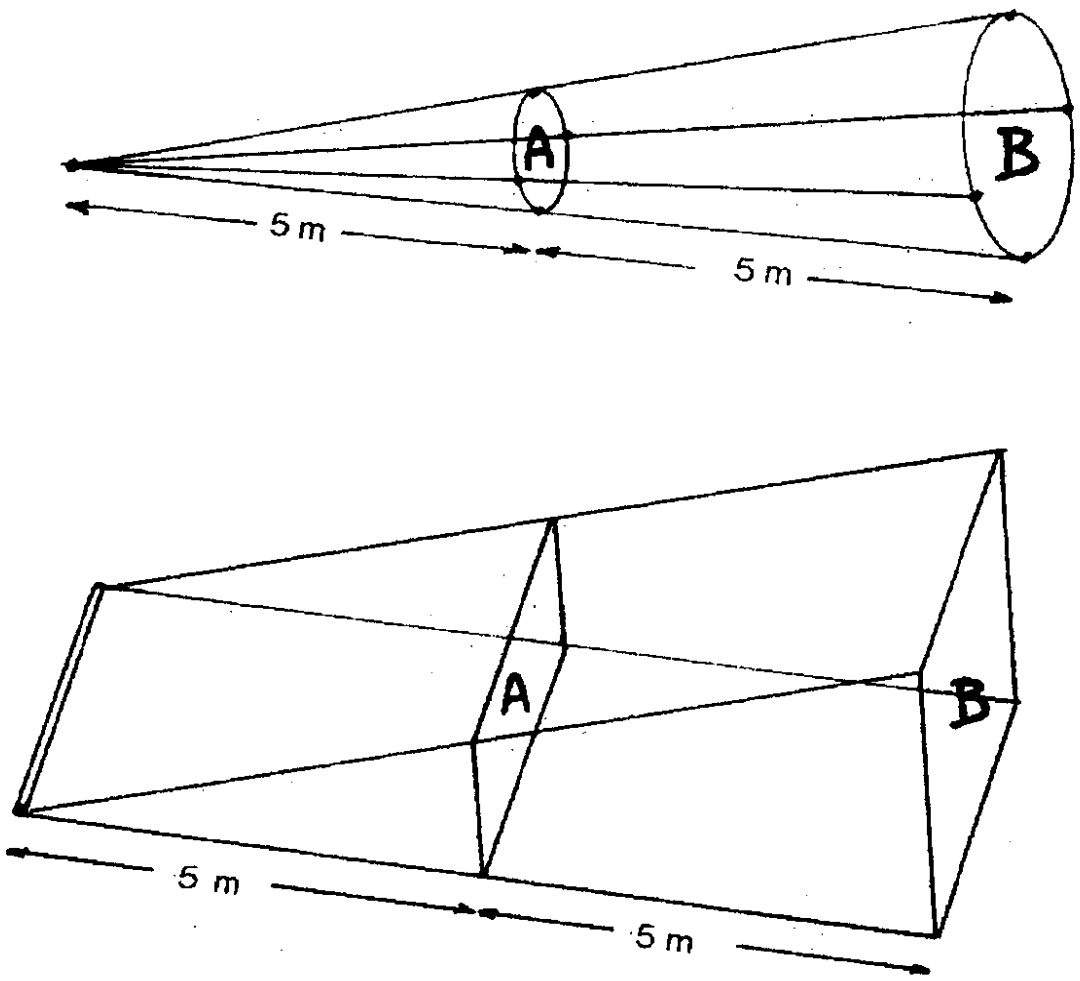


Fig. 6.7. The Spread of Gamma Radiation From a Point Source and a Line Source

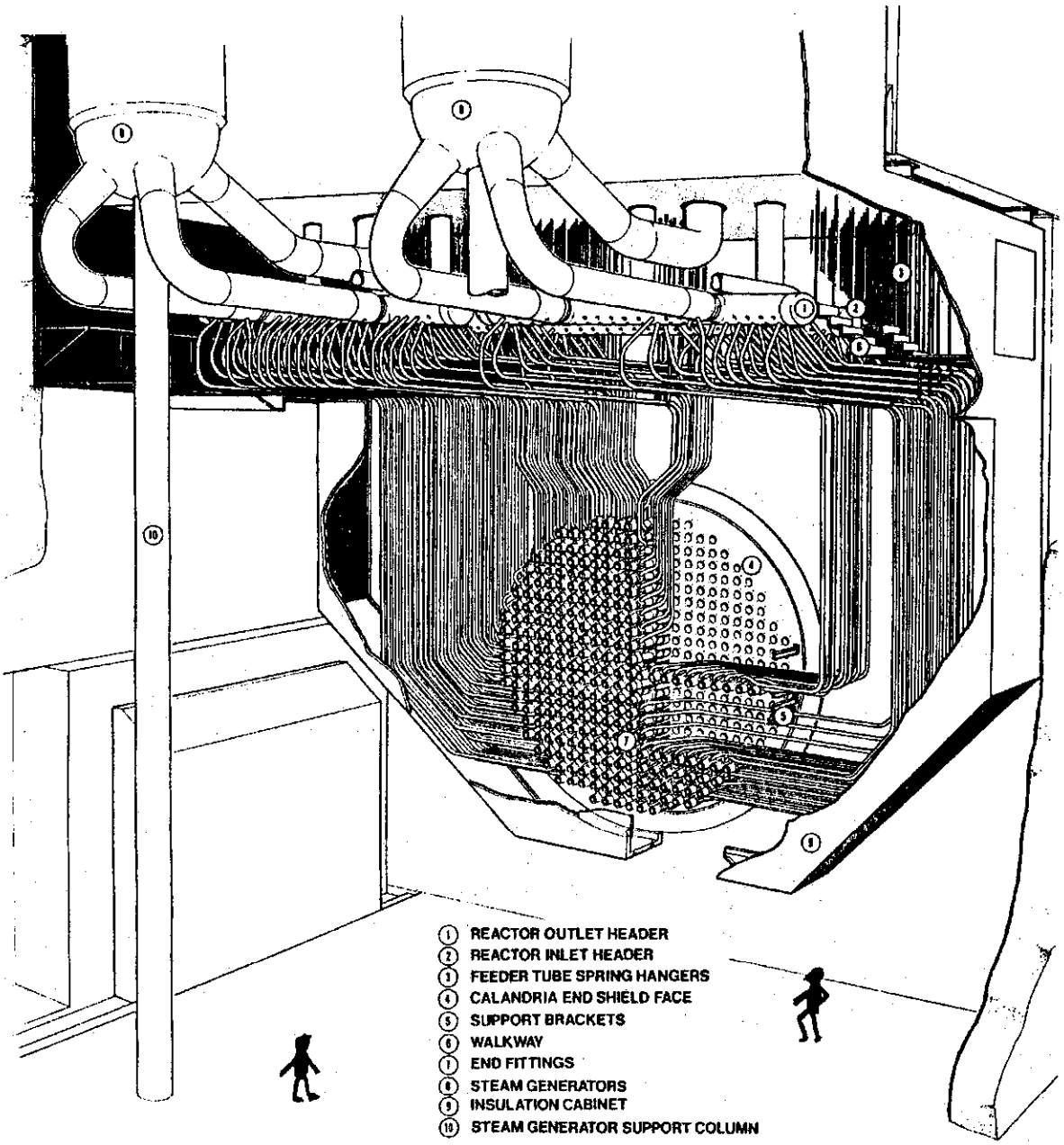


Fig. 6.8. An Example of a Plane Source

ALPHA SHIELDING

no problem: range = 10 cm in air
see Fig. 2.9, p.39

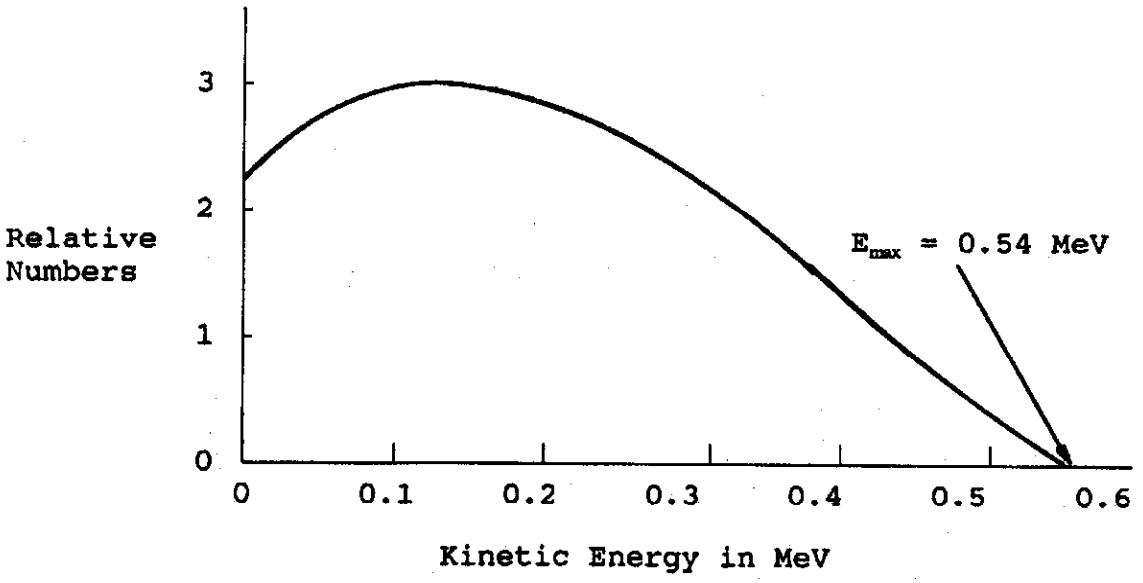
BETA SHIELDING

beta radiation exposes skin and eye lens
range = few metres in air
see Fig. 2.10, 2.11, 2.12 (p.40-42)

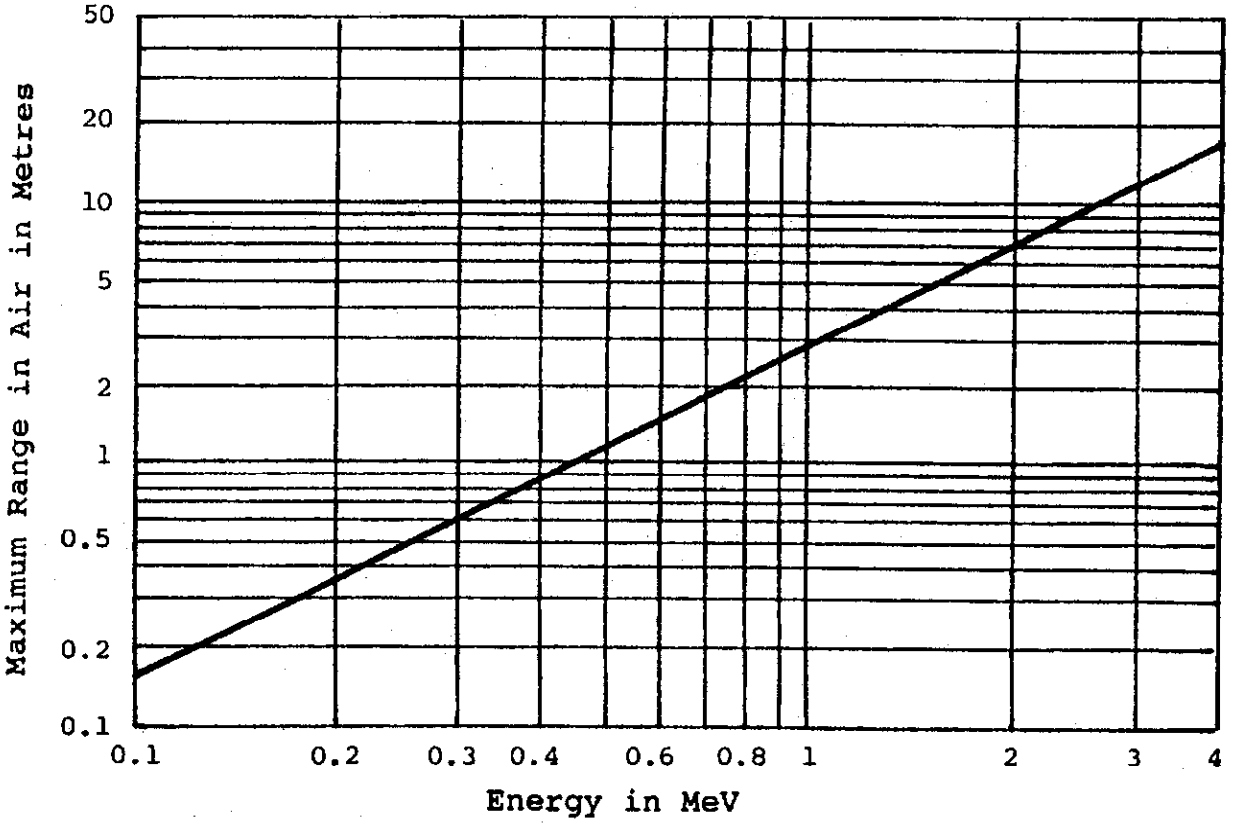
ABSORPTION OF BETA RADIATION

Sr-90 (2.2 MeV) and Tl-204 (0.763 MeV)

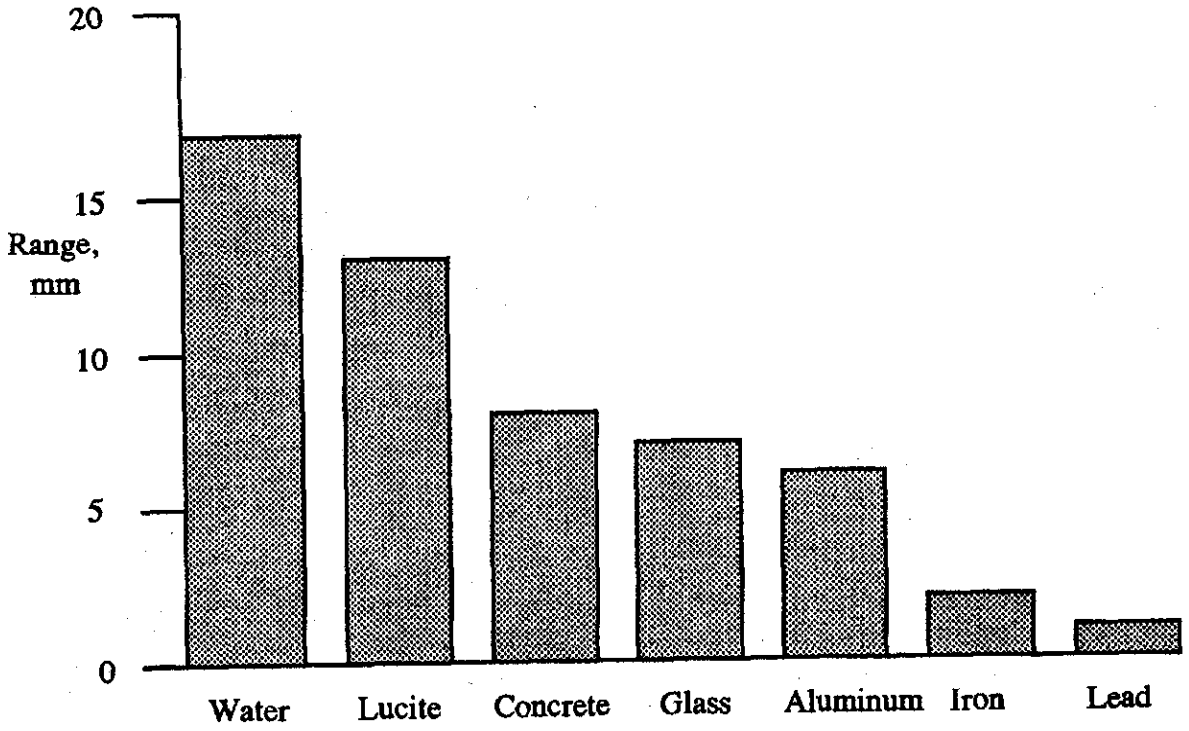
Type of Material	Percent Absorption	
	Sr-90	Tl-204
Safety Glasses (Lens)	95	100
Full-Face Respirator (Lens)	80	100
Plastic Suit	10	60
Rubber Gloves (for suit)	10	60
Cotton Gloves (new)	0	80
Disposable Hood (for suit)	0	25
Brown Coveralls (new)	0	15



The Beta Energy Spectrum of Sr-90.



Penetrating Ability of Beta Radiation in Air



Maximum Range of 3 MeV Beta Particles in Various Materials

GAMMA SHIELDING

Half-Value Layer, HVL

Photoelectric effect (Z^5)

Compton scattering (Z)

Pair Production (Z^2)

Figs. 2.13 (p.43), 2.14 (p.44), 6.9, p.255

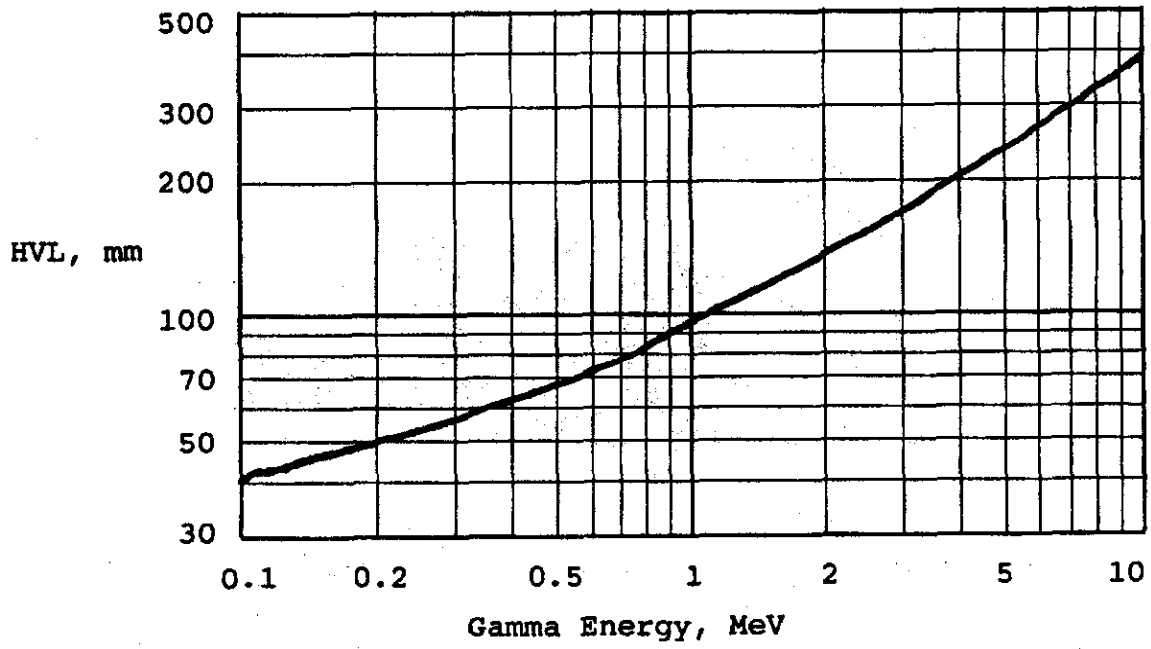
Gamma Build-Up

NEUTRON SHIELDING

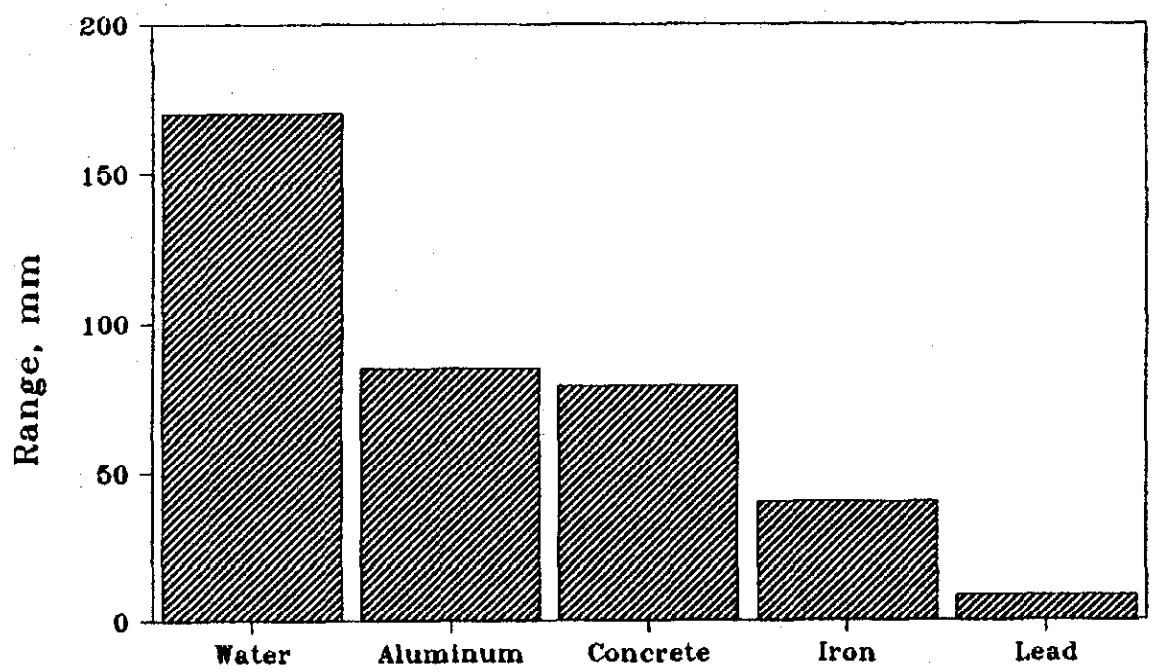
Inelastic scatter: high Z, below 1 MeV

Elastic scatter, low Z, low energy

therefore: composite shields



Half-Value Layer of Water for Various Gamma Energies



Half-Value Layer for 3 MeV Gamma Radiation

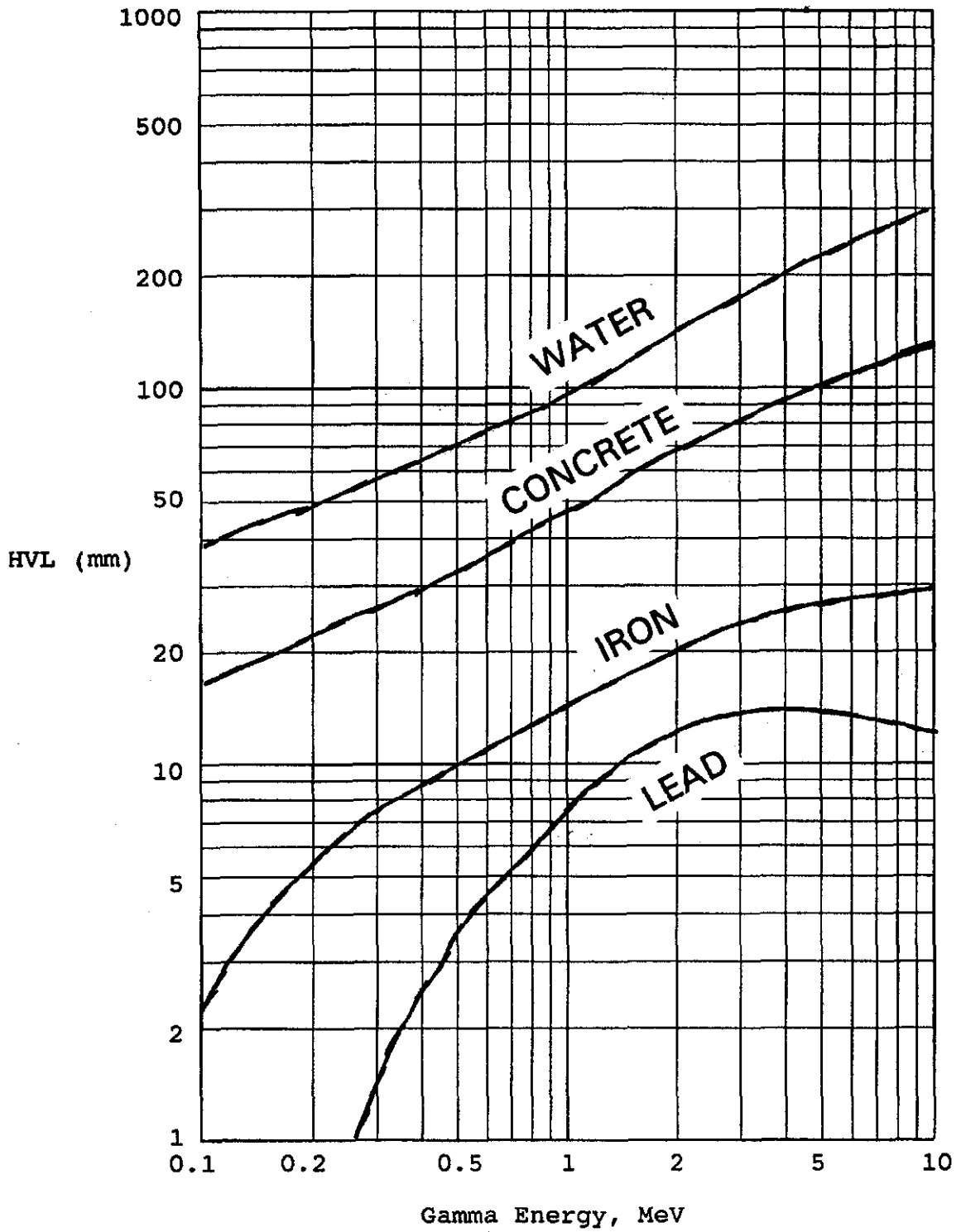


Fig. 6.9. HVLs of Various Materials

TYPES OF SHIELDING

Permanent Shielding

Biological Shield

Thermal Shield

Operational Shield

Shutdown Shield

Shielding Penetrations

SAFETY PRECEDENCE SEQUENCE

1. Eliminate the hazard
2. Minimize the Hazard
3. Install physical barriers
4. Install warning devices
5. Minimize chance for human error
6. Establish procedures
7. Train, motivate, supervise workers
8. Accept hazard as is

ACCESS CONTROL

interfaced to Alarming Area Gamma Monitoring System

Subsystems A, B, C:

Subsystems A

conditioned by Reactor Power

Subsystem B

conditioned by Fuelling Machines

Subsystem C

controlled by Shift Supervisor

Question 5.1 (Biological Effects)

MARKS	QUESTION		
	Rank the following in order of increasing significance and give the reasons for your ranking order:		
10 (18 min)	(a)	(i)	500 mGy from an acute intake of tritium
		(ii)	500 mGy thyroid dose from an acute intake of I-131
		(iii)	50 mGy to the whole body from an acute exposure to gamma radiation
		(iv)	50 mGy to the whole body from an acute exposure to slow neutrons.
10 (18 min)	(b)	(i)	5 mGy to the whole body from an acute exposure to fast neutrons
		(ii)	50 mGy to the whole body from an acute exposure to gamma radiation
		(iii)	50 mGy from an acute intake of tritium
		(iv)	200 mGy thyroid dose from an acute intake of I-131
		(v)	300 mGy from an acute exposure to beta radiation (external).
6 (11 min)	(c)	(i)	500 mSv from an acute intake of tritium,
		(ii)	500 mSv to the thyroid from an acute intake of I-131,
		(iii)	500 mSv acute whole-body exposure to gamma radiation.
	Note: Information from Module 6 on Dose Limits is required to answer this question.		