SHIELDING REQUIREMENTS FOR CT INSTALLATIONS

- The collimated X-ray fan-beam is intercepted by the patient and the detector array, so only secondary radiation is incident on protective barriers.

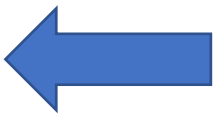
- Operating potential is relatively high, typically in range 80-140kV. Machine workload is also high and large amounts of scattered radiation may be produced.

- Scattered and leakage radiation levels are not isotropic – levels much less in direction of gantry than along table axis. Shielding requirements usually adopt a conservative estimate.

- Shielding determination can be very complex and may depend on a variety of factors including:

Scatter plot for CT machine
Workload (mAs annual total).
(Calculations usually based on 1000 scan annual total)
Distance (size of room, position of CT machine)
Typical mAs per clinical scan
Occupancy of adjacent rooms (including above)
Exterior boundaries

REQUIRED INFORMATION



For any CT machine there will be a minimum room size defined. If the available space is larger, then less shielding may be required.

It may be helpful if some walls boundary the exterior as greater transmission may be permissible to outside the building than into adjacent room (and the walls are likely to be solid).

The ideal room would have walls of 100 mm dense (1950 kg/m^3) concrete block. Some (eg exterior) walls may not need additional shielding. Internal walls may need additional lead shielding, typically Code 5 (2.24 mm LE). Thicker block walls will reduce the necessity for further shielding.

Precise calculation is very dependent on having a precise position of the CT machine in the room and overlaying the scatter plot to determine dose at wall intersects. Once the workload (estimated, in mAs) and occupancy are factored in the required LE of the boundary can be defined.

The preferred basic layout has the control room accessed direct from a corridor or room with the CT machine in a separate room beyond this. There will be a glass vision panel into the CT room from the control room.

The control room itself will not usually be part of the defined controlled area. The entrance door into the CT room from the control room will be governed by a warning sign and automatic warning light. Consideration has to be given to making the warning light fail-safe. It must be possible to isolate the CT machine from the control room.

It may be suitable to have the operator within the scanning room if shielded by adequate panels/glass. Any internal panels must reach the ceiling.

Doors with direct access into the scanning room (not accessed through the control room) may require electrical interlocks.

Data used in calculations:

Scatter plot will give an exposure value in µGy/mAs at each boundary which when multiplied by annual mAs give a total annual dose to that part of the room.

Permitted maximum dose is 300 µSv annually (pedantically at 30 cm the other side of the wall).

The ratio of the two values gives the number of half value thicknesses of any particular material required.

For secondary X-ray radiation @ 90° (practical maximum value) and 150kVp

Lead HVL 0.39 mm; 1/10 value thickness 1.04 mm
Concrete HVL 21 mm; 1/10 value thickness 69.9 mm

Concrete density assumed to be 2350 kg/m³ (US standard) UK standard 2200 kg/m³, so some scaling required.

Experience with these calculations suggest additional shielding is likely to range from zero (100 cm block wall in place) to 2 – 2.5 mm LE (control room boundary, doorways). Note that 100 cm block may still require additional shielding depending on factors listed above.

A ceiling will need additional shielding if there is an occupied room above.

All calculations also depend on a rather empirical adjustment known as **occupancy factor.**

Basically, the lower the occupancy factor the greater the permitted transmission and the less shielding required. Examples (assume most other areas are 100%) are:

Most outside areas	5%
Storage rooms	5%
Corridors	20%
Patient examination/treatment rooms	50%
Toilets	10%

Note that with narrow rooms (eg corridors) what is beyond may become important.