STRUCTURAL SHIELDING AND ROOM LAYOUT REQUIREMENTS FOR STARTING A DIAGNOSTIC X-RAY INSTALLATION

APPLICABLE TO

COMPUTED TOMOGRAHY/FLOUROSCOPY/GENERAL RADIOGRAPHY/ MAMMOGRAPHY/DENTAL RADIOGRAPHY

According to provisions of the Nuclear Regulatory Authority ACT 895 of 2015, section 91 (m) individuals or a group who intend to set up any diagnostic X-ray facility must satisfy the requirements for the design and performance criteria for radiation emitting devices which includes the structural shielding and room layout requirements as indicated below.

1. CONTROL CONSOLE AREA

A protective screen, or shielded console area (with floor dimension not less than 1.5 m x 2.0 m), must be provided for staff at the control panel. The screen should ideally be located in a position adjoining the staff entrance and should be angulated such that that primary and first scatter radiation cannot enter directly the area behind it.

The screen or shielded console area must contain a protective window which has a lead equivalence equal to or greater than the rest of the screen or shielded console area. The viewing window must have dimensions of not less than 300 x 300 mm (0.3 x 0.3 m) to allow the operator to view the patient during exposures and be made of lead glass or lead acrylic.

The operators' protective window shall provide radiation protection equivalence as per a modality as follows:

- not less than 0.8 mm of lead glass or lead acrylic for **mammography**
- not less than 1 mm of lead glass or lead acrylic for **intra-oral dental X-ray**
- not less than 1.5 mm of lead or lead acrylic for **panoramic/cephalometric/dental Computed Tomography (CT)**
- not less than 1.5 mm of lead glass or lead acrylic for **general X-ray and fluoroscopy**
- not less than 2.0 mm of lead for **CT**

These may need to be higher if the protective screen or shielded console area (with the protective window) is less than 2 m from either x-ray tube or patient.

The design of a protective screen or shielded console area must ensure integrity at joints, and between it and the lead glass. The lead glass should overlap by 30−40 mm (0.03 – 0.04 m) into the protective screen or shielded console. The lead glass window should be marked with the lead equivalent thickness.

The protective screen or shielded console area must extend from the floor to a height of not less than 2 m. The protective screen must be wide enough i.e. > 900 mm (0.9 m) to protect the operator from leakage radiation from the tube housing and scattered radiation from the patient. A small gap i.e. < 50 mm (0.05 m) between the floor and screen for wheels is permitted.

2. WALLS

A shielding equivalent to at least 0.5 mm lead or 25.4 mm gypsum wallboards (plasterboards) or 100 mm medium density cement block with fully mortared joints may be sufficient **for shielding mammography rooms**.

The minimum shielding **for intra-oral dental unit** is a standard gypsum wallboard (two layers each of 15.88 mm thickness) or a normal cement block or concrete wall.

For a **panoramic and cephalometric dental unit,** 1.59 mm lead equivalence or a normal cement block or concrete wall will be sufficient.

For **dental CT**, the enclosure should be shielded with 0.79 mm lead equivalence or a normal, cement block or concrete.

The minimum secondary wall thickness of a **general purpose radiography and fluoroscopy** rooms should be 230 mm solid cement block or equivalent, whereas that of the primary shall be 320 mm of solid cement block or equivalent.

For **CT** the minimum wall thickness of the room should be at least 320 mm of solid cement block or equivalence.

Protection needs to extend from the floor to a height of not less than 2 m and be continuous.

Wall shielding must not be compromised at joints and where nails, screws and other fixings are used. The lead thickness should be the same throughout the panels and should overlap with each other at joints, nails and screws perforations. Steel nails and screws provide enough shielding as lead would, therefore additional shielding is not required when used. However, where the edges of two lead sheets meet, continuity must be ensured at the joints with lead battens.

Additional shielded battens may be provided in areas where items have to be fixed to the wall. Where service perforations are required in walls, i.e. electrical socket outlets, light switches, service outlets, ventilation grilles, installation of sinks, cabinets, light boxes, etc., additional lead shielding is required in place of the shielding that is displaced. All joints, perforations, ducts, service outlets, etc. must be shielded.

If the X−ray room is adjacent to a dark room or a storage facility for CR plates, shielding to full height is required to protect films/CR plates located on high−level shelving.

3. DOORS

Doors should be equivalent 1mm of lead or 25.4 mm solid wood **for mammography,** 1.5 mm lead **(for panoramic, dental CT and cephalometric)** and 1.0 mm **(for intra-oral).**

For **general radiography and fluoroscopy units,** 1.5 mm sheet lead provides satisfactory shielding.

For **CT installations**, the doors should generally not have less than 1.5 mm lead.

The room should be designed so that the uninterrupted X−ray beam will not normally be directed towards doors.

Even with this provision the door and doorframe must be shielded against scatter. The shielding must be uninterrupted between double doors, between the door and frame, and between the doorframe and the adjoining wall. Generally the minimum overlap is 1.5 cm.

In the case of a concrete wall, the shielding should overlap the doorframe and wall by a distance at least equivalent to the thickness of the concrete or brick in the wall. Patient doors should be wide enough to allow beds and trolleys to pass through.

Doors should be of solid construction with the lead bonded on both sides by wood or a suitable alternate protective material.

The shielding must run the entire length and width of the door down to a few mm from the floor, and continue on the underside. Doors may include lead glass windows. The shielding in the door frame and door must be effectively uninterrupted and sufficiently overlapped.

Doors and windows should be marked with their lead equivalent thicknesses. Hinges, handles and keyholes should not compromise the shielding.

Access through doors must be controlled by the use of appropriate lights and signs.

4. WINDOWS

Unshielded windows must be at a height of greater than 2 m from the outside ground.

Windows at a height less than the 2 m may be shielded by lead glass or lead acrylic. These should be provided in the form of double−glazing, with plate glass on the outside as lead glass and lead acrylic may be easily damaged and lead glass must be kept dry. Lead glass or lead acrylic windows should be marked with the lead equivalent thickness.

Window frames must also be shielded with sufficient overlap provided between the window and window frame and between the window frame and wall. Alternatively, windows may be shielded by lead blinds or shutters. The blinds should also be marked with the lead equivalent thickness.

The primary beam should not be routinely directed towards a window.

5. FLOORS AND CEILINGS

Consideration must be given to the potential exposure of persons on floors and/or ceiling adjoining x-ray rooms. Precaution is needed if there are penetrations through concrete rafts beneath x-ray tables where either the attenuated primary beam or scattered radiation needs to be considered. The mounting of x-ray tubes close to the ceiling of x-ray rooms for long focal film distance radiography also needs special consideration because persons occupying the floor may be very close to the x-ray tube housing.

Generally, 200 mm solid concrete provides sufficient shielding between floor and/or ceiling of multiple storey buildings.

6. DARKROOM PASS HATCHES

Provision should be made for film pass hatch between the x-ray room and dark room if a darkroom is required. The pass hatch must be lead-lined (at least 0.8 mm lead equivalence for mammography; 1.0 mm lead equivalence for dental, general radiography and fluoroscopy) with the suitable supports and overlaps. The shielding must be on the x-ray room side of the pass hatch.

7. VERTICAL BUCKY

Vertical buckys should not be located on darkroom walls (undeveloped film stocks may be at risk) or walls to areas where members of the public may be in "full" occupancy, without considering a possible need for increasing shielding. Except for walls equivalent to at least 1.4 mm of lead, an additional protective panel may be specified for use behind the vertical bucky, depending on the occupancy of the adjoining area. The panel needs to extend from the floor to a height of around 2000 mm and extend 300 mm either side of the vertical bucky.

7. ROOM SIZES OF UNITS

The **room housing a mammography X-ray** shall not be less than **10 m^2** and no single dimension of the room shall be less than 3m**.** Also, not more than one unit of any type shall be installed in the same room.

A **minimum area of 12 m^2** is required for dental X-ray units. A slightly larger area will be required to comfortably accommodate the widely used combination of panoramic and intra‑oral equipment.

The room housing **fluoroscopy and general radiography** equipment shall not be less than **20 m^2** and no single dimension of the x-ray room shall be less than 4.0m.

For **CT**, a minimum room size of **25 m^2** is required with no single dimension less than 5 m.

NOTE: the services of a qualified expert licensed by NRA may be engaged to advice on complying with the requirements.