DEPARTMENT OF HEALTH

DIRECTORATE: RADIATION CONTROL

GUIDELINES

DESIGN OF X-RAY ROOMS

NOTE: Shielding thickness could be decreased by an increase in distance and/or a decrease in work load

1. General/Fluoroscopy Rooms

1.1 Room size

1.1.1 General radiographic rooms should be approximately 16 m^2. There should be sufficient space for a permanently built protective cubicle.

1.1.2 Fluoroscopic rooms should be approximately 25 m^2.

1.1.3 Special procedure rooms should be considered individually.

1.2. Doors and Walls

1.2.1 Access doors should be of the sliding type giving better radiation protection.

1.2.2 A clearing of 1.5 m is recommended. The overlap should be 100 mm each side.

1.2.3 The doors should be lined with leadsheet of 2 mm thickness.

1.2.4 The walls should be 230 mm kiln baked solid clay brick or 2 mm leadsheet sandwiched between partitioning or 115 mm brick with 6 mm barium plaster.

1.2.4.1 Lead equivalence:

Material	Thickness of material (in mm)	Lead equivalence (in mm) at tube voltage	
		100 kV	**150 kV**
brick	115	1.0	0.9
brick	230	2.4	2.0
barium plaster	6	1.0	0.55
barium plaster	11		1.0

1.2.4.2 Barium plaster mix:
1 part coarse barium sulphate
1 part fine barium sulphate
1 part cement

1.2.5 Walls should be protected up to a height of 2.2 meter.

1.3 **Ceiling and floors**

1.3.1 X-ray rooms should preferably be sited on the ground floor of a building.

1.3.2 If the x-ray room is above ground level the solid concrete slab of density 2.35 g/cm^3 must be of 150 mm thickness.

1.3.3 Thickness of ceiling slabs, if space above is occupied, should not be less than 100 mm.

1.3.4 Single storey buildings do not require a ceiling slab.

1.4 **Windows and air conditioning units**

1.4.1 Windows and air conditioning units should be sited at least 2 m above the floor. Alternatively access near the window must be prevented effectively.

1.4.2 Windows of upper floor x-ray rooms can be of normal height.

1.5 **Protective cubicle**

1.5.1 A protective cubicle allowing space for the control as well as the operator should be constructed in the x-ray room.

1.5.2 The cubicle should be located such that unattenuated direct scatter radiation originating on the examination table or the erect bucky do not reach the operator in the cubicle.

1.5.3 The x-ray control for the system should be fixed within the cubicle and should be at least 1.02 m from any open edge of the cubicle wall which is nearest to the examination table.

1.5.4 The cubicle should have at least one viewing window which will be so placed that the operator can view the patient during any exposure.

1.5.5 The size of the window should be at least 30 cm x 30 cm.

1.5.6 The minimum height of the cubicle is 2.2 meter.

1.5.7 The lead equivalence of the wall or panel as well as the protective glass should be at 2 mm, i.e., 230 mm brick or 115 mm brick barium plastered (6 mm) or 2 mm leadsheet.

1.5.8 The lead glass and protective material must overlap each other by at least 25 mm.

1.6 Change cubicles

1.6.1 Should the change cubicles lead into the x-ray room the doors must be lined with at least 1.5 mm leadsheet.

1.6.2 Access doors into the x-ray room must be lockable from the x-ray room side to prevent entrance during radiation exposures.

1.7 Radiation warning notices / lights

1.7.1 Warning lights are required at the entrances to fluoroscopy rooms. The light must be connected to the generator in such a way that it will illuminate only during activation of the tube.

1.7.2 A radiation warning notice must be displayed at all entrances to x-ray rooms.

2. Special procedure rooms

General guidelines for special procedure rooms:

2.1 Computed tomography

Doors - lined with 1.6mm leadsheet
Walls - The walls should be 230 mm kiln baked solid clay brick or 1.6 mm leadsheet sandwiched between partitioning or 115 mm brick with 4 mm barium plaster.
Protective glass –1.5 mm lead glass (90 mm plate glass).
Warning lights are required outside all entrances to CT rooms. The light must be connected to the generator in such a way that it will illuminate only during activation of the tube.

2.2 CATH LAB

Doors - lined with 2 mm leadsheet
Walls - The walls should be 230 mm kiln baked solid clay brick or 2 mm leadsheet sandwiched between partitioning or 115 mm brick with 6 mm barium plaster.
Protective glass - The lead equivalence of the viewing window must be at least 1 mm of lead.
Warning lights are required outside all direct entrances to Cath labs. The light must be connected to the generator in such a way that it will illuminate only during activation of the tube.

2.3 PAN/CEPH Dental Unit

Doors - lined with 1 mm leadsheet
Walls 115 mm brick or 1 mm leadsheet

2.4 Dental X-ray Unit

No special requirements. In case where partition walls are used, lead plate with dimensions 1m x 1m and 1mm thick, should be attached to the wall. The height of the plate should be 0.5m above the floor in order to fully intercept radiation from the primary beam. This is required only in cases where for example the waiting room is adjacent to the X-ray room with patients sitting at distances less than ±3m from the tube head of the X-ray unit.

2.5 **Fixed C-arm (or mobile used as a fixed unit)**

Doors - lined with 1 mm leadsheet
Walls - 115 mm brick or 1 mm leadsheet

2.6 **Mammographic Unit**

No requirements

3. Specific shielding requirements for radiographic installations can be determined as set out in the attached table 5 of NCRP 49.

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Table 5—*Minimum shielding requirements for radiographic installations*

WUT[a] in mA min			Distance in meters from source to occupied area										
100 kV[b]	125 kV[b]	150 kV[b]											
1,000	400	200	1.5	2.1	3.0	4.2	6.1	8.4	12.2				
500	200	100		1.5	2.1	3.0	4.2	6.1	8.4	12.2			
250	100	50			1.5	2.1	3.0	4.2	6.1	8.4	12.2		
125	50	25				1.5	2.1	3.0	4.2	6.1	8.4	12.2	
62.5	25	12.5					1.5	2.1	3.0	4.2	6.1	8.4	12.2
Type of Area	Material		Primary protective barrier thickness[e]										
Controlled	Lead, mm[c]		1.95	1.65	1.4	1.15	0.9	0.65	0.45	0.3	0.2	0.1	0.1
Noncontrolled	Lead, mm[c]		2.9	2.6	2.3	2.05	1.75	1.5	1.2	0.95	0.75	0.55	0.35
Controlled	Concrete, cm[d]		18	15.5	13.5	11.5	9.5	7	5.5	4	2.5	1.5	0.5
Noncontrolled	Concrete, cm[d]		25	23	20.5	18.5	16.5	14	12	10	8		
			Secondary protective barrier thickness[e]										
Controlled	Lead, mm[c]		0.55	0.45	0.35	0.3	0	0	0	0	0	0	0
Noncontrolled	Lead, mm[c]		1.3	1.05	0.75	0.55	0.45	0.35	0.3	0.05	0	0	0
Controlled	Concrete, cm[d]		5	3.5	2.5	2	0	0	0	0	0	0	0
Noncontrolled	Concrete, cm[d]		11.5	9.5	7.5	5.5	4	3	2	0.5	0	0	0

[a] *W*—weekly workload in mA min, U—use factor, T—occupancy factor.
[b] Peak pulsating x-ray tube potential.
[c] See Table 26 for conversion of thickness in millimeters to inches or to surface density.
[d] Thickness based on concrete density of 2.35 g cm^{-3} (147 lb ft^{-3}).
[e] Barrier thickness based on 150 kV.

THE DESIGH OF SHIELDING WINDOWS USING LEAD GLASS. LEAD ACRYLIC AND PLATE GLASS

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The various properties, costs, and uses of materials for the construction of shielding windows are discussed.

Index terms: Radiations, protective and therapeutic agents and devices • Radiology and radiologists, design of radiological facilities

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For many years, the only alternative to lead glass for shielding windows has been plate glass. Trout *et al.* (1) found that the thickness of plate glass required for single-phase equipment is approximately the same as the thickness of concrete needed to construct an opaque barrier. For example, with 100 kVp and 2.5-mm aluminum filtration, 5 cm of concrete would be equal to 5 cm of plate glass. For the same beam, the data can be used to show that 6 cm of plate glass is equivalent to 6 cm of concrete, which is equivalent to 0.5 mm of lead at 100 kVp (1, 2). For three-phase equipment, an extra half-value layer of glass should be added (1); at 100 kVp, this corresponds to an extra 1.35 cm. Légaré *et al.* (3) found that approximately a 30 % greater thickness of glass over concrete is required for three-phase equipment and plate-glass thicknesses between 2 and 4 cm. The introduction of lead acrylic has provided a third alternative for the design of shielding windows, especially secondary barriers. Table I shows the costs of a shielding window (813 × 1,016 mm [32 × 40 in.]) when the most readily available thicknesses of lead glass, lead acrylic, and plate glass are employed. The plate glass windows are constructed of several layers of 12-mm-thick glass.

Table I: Costs of a Shielding Window*

Material	Thickness (mm)	Lead Equivalent (mm)	Cost ($)‡
Lead acrylic	46†	2.00	1,467
Lead glass	12	1.70	1,105
Lead acrylic	35	1.50	1,030
Lead acrylic	22	1.00	925
Lead acrylic	18	0.80	775
Lead acrylic	12	0.50	550
Plate glass	60	0.50	400
Lead acrylic	7†	0.30	356
Plate glass	36	0.28	240

* 813 × 1,016 mm (32 × 40 in.)
† These thicknesses are available only when specially ordered, but are included here for completeness.
‡ Boston-area prices

For most primary barriers, no significant price difference exists between lead glass and lead acrylic. The shielding requirements for secondary barriers, however, are generally lower and savings can be significant by using lead acrylic or plate glass. For example, if only a 0.5-mm lead-equivalent barrier is required, the cost of the necessary lead acrylic is only 52% and plate glass only 36% of the cost of standard lead glass. If only a 0.25-mm lead-equivalent barrier is required, cost savings are more significant; for example, the cost of three layers of 12-mm-thick plate glass is only half the cost of 12-mm-thick lead acrylic and less than one-quarter the price of standard lead glass. If 7-mm-thick, 0.3-mm lead-equivalent acrylic can be obtained, the cost differential is slightly less.

Besides cost, a designer of shielding windows must also take other factors into account. Both lead glass and plate glass are fragile and most suited to fixed installations such as control booths. Yet, glass is resistant to abrasion and chemicals. Lead acrylic, however, is especially suited for mobile or custom-shaped shields because it is lighter than glass for the same lead-equivalent protection and can be machined easily.[2] Nevertheless, acrylic is damaged by certain chemicals and scratches fairly easily. Of the three materials, only plate glass is completely clear; both lead glass and lead acrylic have a yellowish coloration. Finally, lead glass is stocked in most major distribution centers, while acrylic can only be obtained from a few suppliers. Plate glass is readily available in all areas.

Taking all the factors into account, we use lead glass or lead acrylic for a 1.0–1.7-mm lead-equivalent window, lead acrylic for a 0.5–1.0-mm lead-equivalent window, and plate glass for less than a 0.5-mm lead-equivalent window. For the rare occasions when more than a 1.7-mm lead-equivalent window is required, either lead glass or lead acrylic would be used.

[1] From the Department of Radiology, Dalhousie University and The Cancer Treatment and Research Foundation of Nova Scotia, Victoria General Hospital, Halifax, Nova Scotia, Canada. (Address reprint requests to J.E.A., Cancer Treatment and Research Foundation of Nova Scotia, Victoria General Hospital, Halifax, Nova Scotia B3H 2Y9.) Received Jan. 27, 1982; accepted and revision requested May 25; revision received June 18. sb

[2] Kyowaglas-XA, Nuclear Associates, 100 Voice Rd., Carle Place NY 11514

References

1. Trout ED, Kelley JP, Larson VL. The use of plate glass as shielding material in diagnostic radiologic installations. J Can Assoc Radiol 1974; 25: 173–177.
2. National Council on Radiation Protection. Structural shielding design and evaluation for medical use of x-rays and gamma rays of energies up to 10 MeV. Washington, D C.: NCRP report no. 49, 1976.
3. Légaré JM, Carrières PE, Manseau A, Bibeau C, Robert J, Robidoux N. Blindage contre les grands champs de rayons X primaires et diffusés des appareils triphases au moyen de panneaux de verre, de gypse et de plomb acoustique. Radioprotection 1977; 13:79–95.