APPENDIX A

Table 1 — *Maximum Permissible Doses* [c] *(Dose Equivalents)*

	Average weekly dose [a]	Average 13-week dose	Maximum yearly dose	Maximum accumulated dose [b]
	rem	rem	rem	rem
Controlled areas—Occupational [e,f] Exposure				
Whole body, gonads, blood-forming organs, and lens of eye	0.1	1¼[e]	—	5(N-18)
Skin of whole body	—	7½	30	—
Hands and forearms, head, neck, feet and ankles	—	18¾	75	—
Environs—Nonoccupational Exposure				
Any part of body	.01	—	0.5	—

Notes:

N = Age in years and is greater than 18.

[a] For design purposes only.

[b] When the previous occupational exposure history of an individual is not definitely known, it shall be assumed that he has already received the full dose permitted by the formula 5(N-18).

Persons who were exposed in accordance with the former maximum permissible weekly dose of 0.3 rem and who have accumulated a dose higher than that permitted by the formula shall be restricted to a maximum yearly dose of 5 rem.

[c] Exposure of patients for medical and dental purposes is not included in the maximum permissible dose.

[d] See HSS 157.12 (2) (a) 2.

[e] Where an employe's accumulative exposure is partly due to radiation from radioactive materials and partly to radiation from x-ray units, the limits established in Table I, Appendix A would apply to the sum of the radiation exposures.

[f] Occupationally exposed personnel should receive no more than 10 percent of the limits in the above table when pregnant.

Table 2 — *Typical weekly workloads for busy installations*

Diagnostic	Daily Patient Load	Weekly workload (W) mA min 100 kV[a] or less	125 kV[a]	150 kV[a]
Admission Chest:				
(Miniature, with photo-timing grid)	100	100	—	—
Chest:				
(14 C 17: 3 films per patient, no grid)	60	150	—	—
Cystoscopy	8	600	—	—
Fluoroscopy including spot filming	24	1,500	600	300
Fluoroscopy without spot filming	24	1,000	400	200
Fluoroscopy with image intensification including spot filming	24	750	300	150
General Radiography	24	1,000	400	200
Special Procedures	8	700	280	140
Therapy		**Weekly workload (W)**		
Superficial (up to 150 kV[a])	32	3,000 mA min		
Orthovoltage (200-500 kV[a])	32	20,000 mA min		
Megavoltage (0.5 MV-10 MV)	50	100,000 R at a meter[b]		
Cesium				
50 cm SSD	16	8,000 R at a meter[b]		
50 cm SSD	32	15,000 R at a meter[b]		
60 cm SSD	32	24,000 R at a meter[b]		
Cobalt				
70 cm SSD	32	30,000 R at a meter[b]		
80 cm SSD	32	40,000 R at a meter[b]		
100 cm SSD	32	60,000 R at a meter[b]		

[a] Peak pulsating x-ray tube potential.

[b] R per week at a meter = R m^2 per week.

Table 3 — *Use factors for primary protective barriers* [a]

[To be used only if specific values for a given installation are not available.]

	Radiographic Installations	Therapy Installations
Floor	1	1
Walls	¼	¼
Ceiling	_[b]	_[c]

[a] The use factor for secondary protective barriers is usually 1.

[b] The shielding requirements for the ceiling of a radiographic installation are determined by the secondary barrier requirements rather than by the use factor which is generally extremely low.

[c] The use factor for the ceiling of a therapy installation depends on the type of equipment and techniques used, but usually not more than ¼.

Table 4—*Occupancy factors for non-occupationally* [a] ***exposed persons*** [b]

[For use as a guide in planning shielding where other occupancy data are not available.]

Full Occupancy (T = 1)
Work areas such as offices, laboratories, shops, wards, nurses' stations; living quarters; children's play areas; and occupied space in nearby buildings.
Partial Occupancy (T = ¼)
Corridors, rest rooms, elevators using operators, unattended parking lots.
Occasional Occupancy (T = 1/16) [c]
Waiting rooms, toilets, stairways, unattended elevators, janitors' closets, outside areas used only for pedestrians or vehicular traffic.

[a] The occupancy factor of occupationally exposed persons, in general, may be assumed to be one.

[b] It is advantageous in shielding design to take into account that the occupancy factor in areas adjacent to the radiation room usually is zero for any space more than 2.1 m (7 feet) above the floor as the height of most individuals is less. It is possible therefore, to reduce the thickness of the wall shielding above this height provided the radiation source is below 2.1 m (7 feet). In determining the shielding requirements for wall areas above 2.1 m (7 feet), consideration must be given to the protection of any persons occupying the floor above the areas adjacent to the radiation room. The wall areas over 2.1 m (7 feet) from the floor of the radiation room must also have sufficient shielding to adequately reduce the scattering from the ceiling of adjacent rooms toward occupants.

[c] It should be noted that the use of an occupancy factor or 1/16 may result in full-time exposures in non-controlled areas greater than 2 mR in any one hour or 100 mR in any seven consecutive days.

Table 5 — *Minimum shielding requirements for radiographic installations*

WUT[b] 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										
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[c]										
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.

Table 6 — *Shielding requirements for radiographis film*
[Indicated thickness required to reduce radiation to 0.2 mR for a weekly workload of 100 mA min at 100 KV, 400 mA min at 125 kV, or 200 mA min at 150 kV.[a]]

Storage Period	Barrier Type	Distance from Source to Stored Film							
		2.1 m (7 feet)		3.0 m (10 feet)		4.2 m (14 feet)		6.1 m (20 feet)	
		Lead	Concrete[a]	Lead	Concrete[a]	Lead	Concrete[a]	Lead	Concrete[a]
		mm[c]	cm	mm[c]	cm	mm[c]	cm	mm[c]	cm
1 day	Primary with use factor, U,	2.3	19.5	2.1	18	1.8	15.5	1.5	13.5
1 week	of 1/16	3.0	24	2.7	22	2.4	20.5	2.2	18.5
1 month		3.7	29	3.4	27	3.1	24	2.8	23
1 day	Secondary with use factor, U,	1.7	15	1.5	13	1.2	11	1.0	9
1 week	of 1	2.3	19.5	2.1	17.5	1.8	16	1.5	13.5
1 month		3.0	24	2.8	22	2.5	20	2.2	18.5

Note: In the absence of specific information as to the length of film storage period to be expected, it is suggested that the shielding value for the 1 month's storage period be used.

[a] Peak pulsating x-ray tube potential.

[b] Thickness based on concrete density of 2.35 g cm ^{3} (147 lb ft.$^{-3}$).

[c] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

Table 7 — *Minimum shielding requirements for fluoroscopic installations*

WT [a] in mA min			Distance in meters from source to occupied area											
100 kV [b]	125 kV [b]	150 kV [b]												
2,000	800	400	1.5	2.1	3.0	4.2	6.1	8.4	12.2					
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**		**Secondary protective barrier thickness**											
Controlled	Lead, mm [c]		0.75	0.6	0.45	0.35	0.3	0.05	0	0	0	0	0	
Noncontrolled	Lead, mm [c]		1.6	1.3	1.05	0.75	0.6	0.45	0.35	0.05	0	0	0	
Controlled	Concrete, cm [d]		7.5	5.5	4	3	2.5	0.5	0	0	0	0	0	0
Noncontrolled	Concrete, cm [d]		14	12	10	8	6	4.5	2.5	2.5	0.5	0	0	0

[a] W—weekly workload in mA min, 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}).

Table 8 — *Minimum shielding requirements for 50 kV[a] therapy installations*

WUT[b] in mA min													
		Distance in meters from source to occupied area											
4,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
2,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
1,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
500					1.5	2.1	3.0	4.2	6.1	8.4	12.2		
250						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
125						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
62.5							1.5	2.1	3.0	4.2	6.1	8.4	
31.3								1.5	2.1	3.0	4.2	6.1	
Type of Area	Material	Primary protective barrier thickness[c]											
Controlled	Lead, mm[d]	0.4	0.35	0.3	0.25	0.2	0.2	0.15	0.1	0.1	0.05	0.05	0.05
Noncontrolled	Lead, mm[d]	0.55	0.5	0.45	0.4	0.35	0.3	0.3	0.25	0.2	0.15	0.1	0.1
Controlled	Concrete,cm[e]	4	3.5	3	2.5	2	2	1.5	1	1	0.5	0.5	0.5
Noncontrolled	Concrete,cm[e]	5.5	5	4.5	4	3.5	3	2.5	2.5	2	1.5	1.5	1
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	0.3	0.25	0.2	0.15	0.1	0.05	0.05	0.05	0	0	0	0 k
Noncontrolled	Lead, mm[d]	0.4	0.35	0.3	0.25	0.25	0.2	0.15	0.1	0.1	0.05	0.05	0.05
Controlled	Concrete,cm[e]	2.5	2	1.5	1.5	1	0.5	0.5	0.5	0	0	0	0
Noncontrolled	Concrete,cm[e]	3.5	3.5	3	2.5	2	2	1.5	1	0.5	0.5	0.5	0.5

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

Table 9 — *Minimum shielding requirements for 100 kV[a] therapy installations*

WUT[b] in mA min		Distance in meters from source to occupied area											
4,000		1.5	2.1	3.0	4.2	6.0	8.4	12					
2,000			1.5	2.1	3.0	4.2	6.0	8.4	12				
1,000				1.5	2.1	3.0	4.2	6.0	8.4	12			
500					1.5	2.1	3.0	4.2	6.0	8.4	12		
250						1.5	2.1	3.0	4.2	6.0	8.4	12	
125							1.5	2.1	3.0	4.2	6.0	8.4	12
62.5								1.5	2.1	3.0	4.2	6.0	8.4
31.3									1.5	2.1	3.0	4.2	6.0
Type of Area	**Material**	**Primary protective barrier thickness[c]**											
Controlled	Lead, mm[d]	2.4	2.15	1.85	1.6	1.35	1.1	0.85	0.65	0.45	0.3	0.2	0.1
Noncontrolled	Lead, mm[d]	3.35	3.05	2.75	2.5	2.2	1.95	1.7	1.4	1.2	0.95	0.7	0.5
Controlled	Concrete, cm[e]	18	16	14.5	13	11.5	10	8.5	7	5.5	4	2.5	1.5
Noncontrolled	Concrete, cm[e]	24	22	20.5	18.5	17	15	13.5	12	10.5	9	7.5	6
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	1.9	1.6	1.3	1.05	0.75	0.5	0.25	0.25	0	0	0	0
Noncontrolled	Lead, mm[d]	2.45	2.2	1.95	1.65	1.4	1.1	1.1	0.85	0.5	0.3	0.3	0.3
Controlled	Concrete, cm[e]	11.5	10	8	6.5	5	3	2	2	0	0	0	0
Noncontrolled	Concrete, cm[e]	17	15	13.5	12	10.5	8.5	7	5.5	3.5	2	2	2

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

Table 10 — *Minimum shielding requirements for 150 kV[a] therapy installations*

WUT[b] in mA min		Distance in meters from source to occupied area											
4,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
2,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
1,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
500					1.5	2.1	3.0	4.2	6.2	8.4	12.2		
250						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
125							1.5	2.1	3.0	4.2	6.1	8.4	12.2
62.5								1.5	2.1	3.0	4.2	6.1	8.4
31.3									1.5	2.1	3.0	4.2	6.1
Type of Area	**Material**	**Primary protective barrier thickness[c]**											
Controlled	Lead, mm[d]	3.15	2.85	2.55	2.3	2.0	1.7	1.45	1.2	0.95	0.7	0.5	0.35
Noncontrolled	Lead, mm[d]	4.2	3.85	3.55	3.25	2.95	2.65	2.4	2.1	1.8	1.55	1.3	1.0
Controlled	Concrete, cm[e]	27	25	22.5	20.5	18.5	16	14	11.5	9.5	7.5	5.5	4
Noncontrolled	Concrete, cm[e]	35	32.5	30	27.5	25.5	23.5	21	19	17	14.5	12.5	10.5
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	2.05	1.75	1.45	1.15	0.85	0.55	0.35	0.3	0	0	0	0
Noncontrolled	Lead, mm[d]	3.05	2.75	2.45	2.15	1.85	1.55	1.25	0.95	0.65	0.35	0.3	0
Controlled	Concrete, cm[e]	15	13	11	8.5	6.5	4	2.5	2	0	0	0	0
Noncontrolled	Concrete, cm[e]	22.5	20.5	18.5	16	13.5	11.5	9.5	7	5	2.5	2	0

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

Table 11 — *Minimum shielding requirements for 200 kV[a] therapy installations*

WUT[b] in mA min		Distance in meters from source to occupied area											
40,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
20,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
10,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
5,000					1.5	2.1	3.0	4.1	6.2	8.4	12.2		
2,500						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
1,250							1.5	2.1	3.0	4.2	6.1	8.4	12.2
625								1.5	2.1	3.0	4.2	6.1	8.4
Type of Area	**Material**	**Primary protective barrier thickness[c]**											
Controlled	Lead, mm[d]	6.6	6.1	5.5	5.0	4.5	4.0	3.6	3.1	2.7	2.3	1.9	1.6
Noncontrolled	Lead, mm[d]	8.4	7.6	7.2	6.8	6.2	5.8	5.2	4.7	4.2	3.7	3.2	2.8
Controlled	Concrete,cm[e]	43.5	40.5	37.5	35	32.5	29.5	27	24.5	21.5	19.5	17	14.5
Noncontrolled	Concrete,cm[e]	52	50	46.5	44	41.5	39	36	33.5	30.5	28	25.5	23
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	4.25	3.7	3.2	2.7	2.15	1.7	1.4	1.15	0.9	0.75	0.6	0.05
Noncontrolled	Lead, mm[d]	6.0	5.45	4.95	4.4	3.9	3.4	2.85	2.35	1.8	1.5	1.25	1.0
Controlled	Concrete,cm[e]	27	24.5	22	19.5	17	14	11.5	9.5	7	5	3.5	0.5
Noncontrolled	Concrete,cm[e]	35.5	33	30.5	28	25.5	23	20	17.5	15	12.5	10	8

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm^{-3} (147 lb ft^{-3}).

Table 12 — *Minimum shielding requirements for 250 kV[a] therapy installations*

WUT[b] in mA min		Distance in meters from source to occupied area											
40,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
20,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
10,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
5,000					1.5	2.1	3.0	4.2	6.1	8.4	12.2		
2,500						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
1,250							1.5	2.1	3.0	4.2	6.1	8.4	12.2
625								1.5	2.1	3.0	4.2	6.1	8.4
Type of Area	**Material**	**Primary protective barrier thickness[c]**											
Controlled	Lead, mm[d]	11.45	10.6	9.65	8.8	7.9	7.05	6.2	5.4	4.6	3.9	3.2	2.5
Noncontrolled	Lead, mm[d]	14.55	13.2	12.15	11.8	10.85	9.95	9.05	8.2	7.35	6.5	5.65	4.9
Controlled	Concrete,cm[e]	49	45.5	42.5	40	37	34.5	31.5	29	26	23.5	20.5	18
Noncontrolled	Concrete,cm[e]	58	55.5	52.5	49.5	46.5	43.5	41	38	34	32.5	29.5	27
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	7.2	6.3	5.4	4.5	3.65	2.8	2.3	1.9	1.55	1.25	1.1	0.05
Noncontrolled	Lead, mm[d]	10.1	9.25	8.35	7.5	6.6	5.7	4.85	3.95	3.1	2.5	2.05	1.65
Controlled	Concrete,cm[e]	31.5	28.5	26.5	23.5	20.5	18	15	12.5	9.5	7.5	4.5	0.5
Noncontrolled	Concrete,cm[e]	41	38	36	33	30	27	24	22	19	16	12.5	10

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm^{-3} (147 lb ft^{-3}).

Table 13 — *Minimum shielding requirements for 300 kV[a] therapy installations*

WUT[b] in mA min	Distance in meters from source to occupied area											
40,000	1.5	2.1	3.0	4.2	6.1	8.4	12.2					
20,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2				
10,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2			
5,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2		
2,500					1.5	2.1	3.0	4.2	6.1	8.4	12.2	
1,250						1.5	2.1	3.0	4.2	6.1	8.4	12.2
625							1.5	2.1	3.0	4.2	6.1	8.4

Type of Area	Material	Primary protective barrier thickness[c]											
Controlled	Lead, mm[d]	17.65	16.25	14.85	13.45	12.05	10.75	9.4	8.2	6.9	5.8	4.7	3.75
Noncontrolled	Lead, mm[d]	22.5	21.1	19.6	18.15	16.7	15.3	13.85	12.55	11.2	9.85	8.55	7.35
Controlled	Concrete,cm[e]	55	51.5	48.5	45	42	39	36	33.5	30	27	24	21
Noncontrolled	Concrete,cm[e]	64.5	62	59	56	53	49.5	46.5	43.5	40	37	34	31
		Secondary protective barrier thickness[c]											
Controlled	Lead, mm[d]	12.0	10.55	9.05	7.6	6.1	4.65	3.55	2.95	2.5	2.1	1.8	1.6
Noncontrolled	Lead, mm[d]	16.9	15.45	13.95	12.5	11.05	9.55	8.1	6.6	5.15	3.75	3.1	2.65
Controlled	Concrete,cm[e]	33	30	27	24	21	18	14.5	11.5	9	6	3.5	1.5
Noncontrolled	Concrete,cm[e]	43	40	37	34	31	28	25	22.5	19	15.5	12.5	10

[a] Peak pulsating x-ray tube potential.

[b] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[c] Constant potential requires about 20 percent larger thicknesses of lead and about 10 percent larger thicknesses of concrete than those given here for pulsating potential.

[d] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[e] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

Table 14 — *Minimum shielding requirements for 1 MV therapy installations*

WUT[b] in mA min	Distance in meters from source to occupied area											
5,000	1.5	2.1	3.0	4.2	6.1	8.4	12.2					
2,500		1.5	2.1	3.0	4.2	6.1	8.4	12.2				
1,250			1.5	2.1	3.0	4.2	6.1	8.4	12.2			
625				1.5	2.1	3.0	4.2	6.1	8.4	12.2		
313					1.5	2.1	3.0	4.2	6.1	8.4	12.2	
156						1.5	2.1	3.0	4.2	6.1	8.4	12.2
78							1.5	2.1	3.0	4.2	6.1	8.4

Type of Area	Material	Primary protective barrier thickness											
Controlled	Lead, cm[b]	11	10.5	10	9	9	7	6.5	6	5	4	3.5	3
Noncontrolled	Lead, cm[b]	14	13	12.5	11.5	11	10	9	8.5	7.5	7	6	5
Controlled	Concrete,cm[c]	70	66	62	57	53	48	43	39	35	30	26	21
Noncontrolled	Concrete,cm[c]	85	81	77	72	68	63	59	54	50	45	40	36
		Secondary protective barrier thickness[d]											
Controlled	Lead, cm[b]	6	5.5	5.5	4.5	4	3	2.5	2	1.5	1	0.5	0
Noncontrolled	Lead, cm[b]	9	8	7	6.5	5.5	5	4.5	4	3.5	2.5	2	1.5
Controlled	Concrete,cm[c]	46	42	37	33	28.5	24	19	15	10.5	6	1.5	0
Noncontrolled	Concrete,cm[c]	61	57	52	48	43	39	35	30	25	20.5	16.5	12

[a] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[b] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[c] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

[d] Shielding for tube housing leakage based on a weekly workload (WUT) of 5,000 mA min corresponding to a weekly workload (WUT) of 100,000 R at 1 meter (X_n = 20 R per mA min at 1 meter).

Table 15 — *Minimum shielding requirements for 2 MV therapy installations*

WUT [b] in mA min		Distance in meters from source to occupied area											
350		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
175			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
87.5				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
44					1.5	2.1	3.0	4.2	6.1	8.4	12.2		
22						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
11							1.5	2.1	3.0	4.2	6.1	8.4	12.2
5.5								1.5	2.1	3.0	4.2	6.1	8.4
Type of Area	**Material**	**Primary protective barrier thickness**											
Controlled	Lead, cm[b]	22	21	19.5	18.5	17	16	15	13.5	12.5	11	10	9
Noncontrolled	Lead, cm[b]	26	25	24	22.5	21.5	30	19	18	16.5	15.5	14	13
Controlled	Concrete,cm[c]	118	111	105	98	92	86	80	74	67.5	61	57	49.5
Noncontrolled	Concrete,cm[c]	138	132	126	119	113	107	101	95	89	82.5	78	70.5
		Secondary protective barrier thickness [d]											
Controlled	Lead, cm[b]	11	10	8.5	7.5	6	6	4.5	3.5	2	1	0	0
Noncontrolled	Lead, cm[b]	15.5	14	12.5	11.5	10	10	9	7.5	6.5	5	4	2.5
Controlled	Concrete,cm[c]	63	55.5	49.5	44	37	31	24.5	18.5	12.5	6	0	0
Noncontrolled	Concrete,cm[c]	84.5	76.5	70.5	65.5	58	52	46	39.5	33.5	27	20.5	14.5

[a] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[b] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[c] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

[d] Shielding for tube housing leakage based on a weekly workload (WUT) of 350 mA min corresponding to a weekly workload (WUT) of 100,000 R at 1 meter (X_n = 300 R per mA min at 1 meter).

Table 16 — *Minimum shielding requirements for 3 MV therapy installations*

WUT [b] in mA min		Distance in meters from source to occupied area											
150		1.5	2.1	3.0	4.2	6.1	8.4	12.2					
75			1.5	2.1	3.0	4.2	6.1	8.4	12.2				
37.5				1.5	2.1	3.0	4.2	6.1	8.4	12.2			
18.75					1.5	2.1	3.0	4.2	6.1	8.4	12.2		
9.5						1.5	2.1	3.0	4.2	6.1	8.4	12.2	
4.75							1.5	2.1	3.0	4.2	6.1	8.4	12.2
2.35								1.5	2.1	3.0	4.2	6.1	8.4
Type of Area	**Material**	**Primary protective barrier thickness**											
Controlled	Lead, cm[b]	30	28	26.5	25	23.5	22	20.5	19	17.5	16	14.5	13
Noncontrolled	Lead, cm[b]	35	33	31.5	30	28.5	27	25	24	22.5	21	19.5	18
Controlled	Concrete,cm[c]	150	146	138	131	124	116	109	101	94	86	79	71
Noncontrolled	Concrete,cm[c]	180	171	169	156	150	141	134	126	118	111	103	96
		Secondary protective barrier thickness [d]											
Controlled	Lead, cm[b]	13	11.5	10	8.5	7	7	5.5	4	2.5	1	0	0
Noncontrolled	Lead, cm[b]	17.5	16.5	15	13.5	12	12	10.5	9	7.5	6	4.5	3
Controlled	Concrete,cm[c]	69	62	54	54	46	38.5	31.5	23.5	15	8	0	0
Noncontrolled	Concrete,cm[c]	93	86	78	78	70	62.5	55.5	48	39.5	32	24.5	17

[a] W—weekly workload in mA min, U—use factor, T—occupancy factor.

[b] See Table 26 for conversion of thickness in millimeters to inches or to surface density.

[c] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

[d] Shielding for tube housing leakage based on a weekly workload (WUT) of 150 mA min corresponding to a weekly workload (WUT) of 100,000 R at 1 meter (X_n = 700 R per mA min at 1 meter).

Table 17 — *Minimum shielding requirements for 4 MV therapy installations for controlled areas* [a]

WUT [b] in R at 1 meter	Distance in meters from source to occupied area									
160,000	1.5	2.1	3.0	4.2	6.1	8.4	12.2	17		
80,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2	17	
40,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2	17
20,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2
10,000					1.5	2.1	3.0	4.2	6.1	8.4
5,000						1.5	2.1	3.0	4.2	6.1
2,500							1.5	2.1	3.0	4.2

Type of Protective Barrier	Material	TVL cm	Thickness of barrier in cm									
Primary	Concrete [c]	29.2	171	162	153	144	136	127	118	109	101	92
Primary	Lead	5.3	31	29.5	28	26.5	24.5	23	21.5	19.5	18	16.5
Primary	Iron [e]	9.1	53.5	50.5	48	45	42.5	39.5	37	34	31.5	28.5
Leakage [d] 0.1 percent	Concrete [c]	29.2	83	75	66	57	48	39	31	22	13	4
Leakage [d] 0.1 percent	Lead	5.3	15	13.5	12	11.5	10	8.5	7	5.5	4	2.5

[a] For a weekly design level of 100 mR; add one tenth-value layer (TVL) for noncontrolled areas to reduce to 10 mR.

[b] W—weekly workload in R at 1 m, U—use factor, T—occupancy factor.

[c] Thickness based on concrete density of 2.35 g cm^{-3} (147 lb ft^{-3}).

[d] Shielding for leakage radiation from tube housing.

[e] Thickness based on iron density of 7.8 g cm^{-3} (488 lb ft^{-3}).

Table 18 — *Minimum shielding requirements for 6 MV therapy installations for controlled areas* [a]

WUT [b] in R at 1 meter	Distance in meters from source to occupied area									
160,000	1.5	2.1	3.0	4.2	6.1	8.4	12.2	17		
80,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2	17	
40,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2	17
20,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2
10,000					1.5	2.1	3.0	4.2	6.1	8.4
5,000						1.5	2.1	3.0	4.2	6.1
2,500							1.5	2.1	3.0	4.2

Type of Protective Barrier	Material	TVL cm	Thickness of barrier in cm										
Primary	Concrete [c]	34.5	202	192	182	172	161	151	141	131	119	109
Primary	Lead	5.6	33	31	29.5	27.5	26	24.5	22.5	21	19	17.5
Primary	Iron [e]	9.9	58	55	52	49	46	43	40	37	34	31
Leakage [d] 0.1 percent	Concrete [c]	34.5	98.5	88	77.5	67.5	57	46.5	36	25.5	15.5	5
Leakage [d] 0.1 percent	Lead	5.6	16	14.5	12.5	11	9	7.5	6	4	2.5	1
Leakage [d] 0.1 percent	Iron	9.9	28.5	25.5	22.5	19.5	16.5	13.5	10.5	7.5	4.5	1.5
Scatter [f]	Concrete [c]											
30°		26.7	98	89.5	82	74	66	58	50	42	34	26
45°		23.4	72	65	58	51	44	37	30	23	16	8.5
60°		20.3	58	52	46	40	34	28	21.5	15	9	3
90°		17.8	46.5	41	36	30.5	25	20	14.5	9	4	0
135°		14.5	36	31.5	27	22.5	18.5	13.5	9	5	0	0

[a] For a weekly design level of 100 mR; add one tenth-value layer *(TVL)* for noncontrolled areas to reduce to 10 mR.

[b] W—weekly workload in R at 1 m, U—use factor, T—occupancy factor.

[c] Thickness for primary and leakage protective barriers based on concrete density of 2.35 g cm^{-3} (147 lb ft^{-3}).

[d] Shielding for leakage radiation from tube housing.

[e] Thickness based on iron density of 7.8 g cm^{-3} (488 lb ft^{-3}).

[f] Scatter protective barrier thickness based on Karzmark and Capone [23].

Table 19 — *Minimum shielding requirements for 8 MV therapy installations for controlled areas* [a]

WUT [b] in R at 1 meter		Distance in meters from source to occupied area									
160,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2	17		
80,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2	17	
40,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2	17
20,000					1.5	2.1	3.0	4.2	6.1	8.4	12.2
10,000						1.5	2.1	3.0	4.2	6.1	8.4
5,000							1.5	2.1	3.0	4.2	6.1
2,500								1.5	2.1	3.0	4.2
Type of Protective Barrier	Material	Thickness of barrier in cm									
Primary	Concrete [c]	233	212	200	189	177	166	154	143	131	120
Primary	Lead	33	31.5	29.5	28	26	24.5	23	21	19.5	17.5
Primary	Iron [e]	60.5	57.5	54	51	48	45	41.5	38.5	35.5	32.5
Leakage [d] 0.1 percent	Concrete [c]	108	96.5	85.5	74	62.5	51.5	39.5	28.5	16.5	5.5
Leakage [d] 0.1 percent	Lead	16	14.5	12.5	11	9.5	7.5	6	4	2.5	1
Leakage [d] 0.1 percent	Iron	29.5	26.5	23	20	17	14	11	7.5	4.5	1.5

[a] For a weekly design level of 100 mR; add one tenth-value layer *(TVL)* for noncontrolled areas to reduce to 10 mR (see Table 27).

[b] W—weekly workload in R at 1 m, U—use factor, T—occupancy factor.

[c] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

[d] Shielding for leakage radiation from tube housing.

[e] Thickness based on iron density of 7.8 g cm $^{-3}$ (488 lb ft $^{-3}$).

Table 20 — *Minimum shielding requirements for 10 MV therapy installations for controlled areas*[a]

WUT[b] in R at 1 meter		Distance in meters from source to occupied area									
160,000		1.5	2.1	3.0	4.2	6.1	8.4	12.2	17		
80,000			1.5	2.1	3.0	4.2	6.1	8.4	12.2	17	
40,000				1.5	2.1	3.0	4.2	6.1	8.4	12.2	17
20,000					1.5	2.1	3.0	4.2	6.1	8.4	12.2
10,000						1.5	2.1	3.0	4.2	6.1	8.4
5,000							1.5	2.1	3.0	4.2	6.1
2,500								1.5	2.1	3.0	4.2
Type of Protective Barrier	**Material**	**Thickness of barrier in cm**									
Primary	Concrete[c]	234	222	210	198	186	174	162	150	138	126
Primary	Lead	32.5	30.5	29	27.5	25.5	24	22.5	20.5	19	17.5
Primary	Iron[e]	61.5	58.5	55.5	52	49	46	42.5	39.5	36	33
Leakage[d] 0.1 percent	Concrete[c]	114	102	90	77.5	66	53.5	42	29.5	17.5	6
Leakage[d] 0.1 percent	Lead	16.5	14	12.5	11	9.5	7.5	6	4	2.5	1
Leakage[d] 0.1 percent	Iron[e]	30	26.5	23.5	20.5	17.5	14	11	7.5	4.5	1.5

[a] For a weekly design level of 100 mR; add one tenth-value layer (TVL) for noncontrolled areas to reduce to 10 mR (see Table 23).

[b] W—weekly workload in R at 1 m, U—use factor, T—occupancy factor.

[c] Thickness based on concrete density of 2.35 g cm $^{-3}$ (147 lb ft $^{-3}$).

[d] Shielding for leakage radiation from tube housing.

[e] Thickness based on iron density of 7.8 g cm $^{-3}$ (488 lb ft $^{-3}$).

Table 21 — *Densities of commercial building materials*

Material	Range of Density[a]	Average Density[b] g cm $^{-3}$	Average Density[b] lb ft $^{-3}$
Barium sulfate (natural barite)	—	4.5	280
Barytes concrete	3.6 to 4.1	3.6	210
Brick, soft	1.4 to 1.9	1.65	103
hard	1.8 to 2.3	2.05	128
Earth, dry, packed	—	1.5	95
Ferrophosphorus aggregate concrete	6.0	4.8	300
Granite	2.6 to 2.7	2.65	165
Ilmenite aggregate concrete	4.4 to 4.7	3.85	240
Lead	—	11.36	709
Lead glass	—	3.27	205
Lead glass, high density	—	6.22	387
Limestone	2.1 to 2.8	2.46	153
Marble	2.6 to 2.86	2.7	170
Sand, dry, packed	1.6 to 1.9	—	100-120
Sand plaster	—	1.54	96
Concrete	2.25 to 2.4	2.35	147
Steel	—	7.8	489
Tile	1.6 to 2.5	1.9	118

[a] Density values for the concrete aggregates are given for the aggregate only.

[b] Density values are given for the concrete made from the specified aggregate.

Note: Concrete blocks and cinder blocks vary too much to be listed.

Reference: Mark's Mechanical Engineering Handbook, 5th ed. (McGraw-Hill, New York, 1941); excerpts from a table (pp. 522-523), Approximate Specific Gravity and Density.

Table 22 — *Commercial lead sheets*

Thickness		Weight in Pounds for a 1 Square Foot Section	
Inches	Millimeter equivalent	Nominal weight	Actual weight
1/64	0.40	1	0.92
3/128	0.60	1½	1.38
1/32	0.79	2	1.85
5/128	1.00	2½	2.31
3/64	1.19	3	2.76
7/128	1.39	3½	3.22
—	1.50	—	3.48
1/16	1.58	4	3.69
5/64	1.98	5	4.60
3/32	2.38	6	5.53
—	2.5	—	5.80
—	3.0	—	6.98
1/8	3.17	8	7.38
5/32	3.97	10	9.22
3/16	4.76	12	11.06
7/32	5.55	14	12.9
1/4	6.35	16	14.75
1/3	8.47	20	19.66
2/5	10.76	24	23.60
1/2	12.70	30	29.50
2/3	16.93	40	39.33
1	25.40	60	59.00

Notes:

1. The density of commerically rolled lead is 11.36 g cm $^{-3}$.*

2. The commercial tolerances are ± 0.005 inches for lead up to 7/128 and ± 1/32 heavier sheets. *

3. It should be noted that lead sheet less than 1/32 inch thick is frequently more expensive than heavier sheet in cost of material and cost of installation.

* Lead Industries Association, Inc., 292 Madison Avenue, New York.

Table 23 — *Half-value and tenth-value layers*

Approximate values obtained at high attenuation for the indicated peak voltage values under broad-beam conditions; with low attenuation these values will be significantly less.

Peak Voltage (KV)	Attenuation Material: Lead (mm)		Concrete (cm)		Iron (cm)	
	HVL	*TVL*	*HVL*	*TVL*	*HVL*	*TVL*
50	0.06	0.17	0.43	1.5		
70	0.17	0.52	0.84	2.8		
100	0.27	0.88	1.6	5.3		
125	0.28	0.93	2.0	6.6		
150	0.30	0.99	2.24	7.4		
200	0.52	1.7	2.5	8.4		
250	0.88	2.9	2.8	9.4		
300	1.47	4.8	3.1	10.4		
400	2.5	8.3	3.3	10.9		
500	3.6	11.9	3.6	11.7		
1,000	7.9	26	4.4	14.7		
2,000	12.5	42	6.4	21		
3,000	14.5	48.5	7.4	24.5		
4,000	16	53	8.8	29.2	2.7	9.1
6,000	16.9	56	10.4	34.5	3.0	9.9
8,000	16.9	56	11.4	37.8	3.1	10.3
10,000	16.6	55	11.9	39.6	3.2	10.5
Cesium-137	6.5	21.6	4.8	15.7	1.6	5.3
Cobalt-60	12	40	6.2	20.6	2.1	6.9
Radium	16.6	55	6.9	23.4	2.2	7.4

Table 24 — *Selected gamma-ray sources*

Radionuclide	Atomic Number	Half Life	Gamma Energy MeV	Half-Value Layer[a]			Tenth-Value Layer[a]			Specific Gamma-Ray Constant[b] R cm² per mCi h
				Concrete cm	Steel cm	Lead cm	Concrete cm	Steel cm	Lead cm	
Cesium-137	55	27y	0.66	4.8	1.6	0.65	15.7	5.3	2.1	3.2
Cobalt-60	27	5.24y	1.17, 1.33	6.2	2.1	1.20	20.6	6.9	4.0	13
Gold-198	79	2.7d	0.41	4.1	—	0.33	13.5	—	1.1	2.32
Iridium-192	77	74d	0.13 to 1.06	4.3	1.3	0.60	14.7	4.3	2.0	5.0
Radium-226	88	1622y	0.047 to 2.4	6.9	2.2	1.66	23.4	7.4	5.5	8.25[c]

[a] Approximate values obtained with large attenuation.

[b] These values assume that gamma absorption in the source is negligible. Value in R per millicurie-hour at 1 cm can be converted to R per Ci-h at 1 meter by multiplying the number in this column by 0.10

[c] This value assumes that the source is sealed with a platinum capsule (0.5 mm wall thickness), with units of R per mg h at 1 cm.

APPENDIX B

SHIELDING REQUIREMENTS

Table 1 — Shielding requirements for dental offices and adjacent areas for 70 KVP operation

Table 2 — Shielding requirements for dental offices and adjacent areas for 100 KVP operation

Table 1

SHIELDING REQUIREMENTS FOR DENTAL OFFICES AND ADJACENT AREAS FOR 70 KVP OPERATION

Workload	Type of Area to be Protected	Name of Barrier	Distance From Tube to Occupied Area				
			3 feet	5 feet	7 feet	10 feet	14 feet
			mm	*mm*	*mm*	*mm*	*mm*
1,200 ma-sec/wk. or 12—2 second exposures/day at 10 ma	Controlled Primary	Wall	0.25	0.15	0.1	0.05	0.0
		Floor or ceiling	0.1	0.05	0.0	0.0	0.0
	Controlled Secondary	Wall, floor or ceiling	0.05	0.0	0.0	0.0	0.0
	Uncontrolled Primary	Wall	0.55	0.4	0.3	0.25	0.2
		Floor or ceiling	0.35	0.25	0.2	0.1	0.05
	Uncontrolled Secondary	Wall, floor or ceiling	0.25	0.15	0.1	0.05	0.0
2,500 ma-sec/wk. or 25—2 second exposures/day at 10 ma	Controlled Primary	Wall	0.3	0.2	0.15	0.1	0.05
		Floor or ceiling	0.15	0.1	0.05	0.0	0.0
	Controlled Secondary	Wall, floor or ceiling	0.1	0.0	0.0	0.0	0.0
	Uncontrolled Primary	Wall	0.7	0.5	0.4	0.3	0.25
		Floor or ceiling	0.45	0.3	0.25	0.2	0.1
	Uncontrolled Secondary	Wall, floor or ceiling	0.3	0.2	0.15	0.1	0.05
5,000 ma-sec/wk. or 50—2 second exposures/day at 10 ma	Controlled Primary	Wall	0.4	0.3	0.2	0.15	0.1
		Floor or ceiling	0.25	0.15	0.1	0.05	0.0
	Controlled Secondary	Wall, floor or ceiling	0.15	0.1	0.0	0.0	0.0
	Uncontrolled Primary	Wall	0.8	0.65	0.5	0.4	0.3
		Floor or ceiling	0.6	0.4	0.3	0.25	0.2
	Uncontrolled Secondary	Wall, floor or ceiling	0.4	0.3	0.2	0.15	0.1

Table 2

SHIELDING REQUIREMENTS FOR DENTAL OFFICES AND ADJACENT AREAS FOR 100 KVP OPERATION

Workload	Type of Area to be Protected	Name of Barrier	Distance From Tube to Occupied Area 3 feet	5 feet	7 feet	10 feet	14 feet
			mm	*mm*	*mm*	*mm*	*mm*
	Controlled Primary	Wall	0.4	0.2	0.1	0.0	0.0
		Floor or ceiling	0.15	0.05	0.0	0.0	0.0
500 ma-sec/wk. or 10—1 second exposures/day at 10 ma	Controlled Secondary	Wall, floor or ceiling	0.0	0.0	0.0	0.0	0.0
	Uncontrolled Primary	Wall	1.0	0.7	0.5	0.35	0.25
		Floor or ceiling	0.65	0.35	0.25	0.15	0.05
	Uncontrolled Secondary	Wall, floor or ceiling	0.4	0.2	0.1	0.0	0.0
	Controlled Primary	Wall	0.55	0.35	0.2	0.1	0.0
		Floor or ceiling	0.25	0.1	0.0	0.0	0.0
1,000 ma-sec/wk. or 20—1 second exposures/day at 10 ma	Controlled Secondary	Wall, floor or ceiling	0.1	0.0	0.0	0.0	0.0
	Uncontrolled Primary	Wall	1.2	0.9	0.7	0.5	0.35
		Floor or ceiling	0.8	0.5	0.35	0.25	0.15
	Uncontrolled Secondary	Wall, floor or ceiling	0.55	0.35	0.2	0.1	0.0
	Controlled Primary	Wall	0.7	0.4	0.3	0.15	0.05
		Floor or ceiling	0.35	0.15	0.1	0.0	0.0
2,000 ma-sec/wk. or 40—1 second exposures/day at 10 ma	Controlled Secondary	Wall, floor or ceiling	0.15	0.05	0.0	0.0	0.0
	Uncontrolled Primary	Wall	1.35	1.0	0.85	0.6	0.45
		Floor or ceiling	0.9	0.65	0.45	0.3	0.2
	Uncontrolled Secondary	Wall, floor or ceiling	0.7	0.4	0.3	0.15	0.05

Form RAD-A
1982

APPENDIX C

Wisconsin Department of Health and Social Services

CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

See Instructions on the Back

RADIATION PROTECTION SECTION
DIVISION OF HEALTH
P.O. BOX 309
MADISON, WISCONSIN 53701

INSTRUCTIONS FOR PREPARATION OF FORM RAD-A

The preparation and safekeeping of this form or a clear and legible record containing all the information required on this form, is required pursuant to s. *HSS 157.12 (5) (a) of the Radiation Protection Code* as a current record of occupational external radiation exposures. Such a record must be maintained for each individual for whom personnel monitoring is required under s. *HSS 157.12 (3) (b)*. Note that a separate copy of this form is to be used for recording external exposure to whole body; and skin of whole body; or hands and forearms, feet and ankles as provided by Item 5 below. Listed below by item are instructions and additional information directly pertinent to completing this form.

IDENTIFICATION

Item 1. Self-explanatory.

Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.

Item 3. Self-explanatory.

Item 4. Enter the age in full years. This is called "N" when used in calculating the Maximum Permissible Dose. N is equal to the number of years of age of the individual on his last birthday.

OCCUPATIONAL EXPOSURE

Item 5. Use separate form to record exposure to whole body; skin of whole body; hands and forearms, feet and ankles—Specify in Item 5.

If an individual receives a radiation dose to the skin of the whole body from radiation of half-value layer less than 5 cm. of tissue, the dose to the skin of the whole body should be recorded on a separate form, unless the dose to the skin of the whole body as indicated by personnel monitoring devices has been included as dose to the whole body on a form maintained for recording whole body exposures.

If an individual receives a radiation dose to the hands and forearms, or feet and ankles, the dose to those portions of the body should be recorded on separate forms unless the dose to those parts of the body as indicated by personnel monitoring devices have been included as doses to the whole body on a form maintained for recording whole body exposure.

"Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

Item 6. The permissible dose is taken from (a) previous records of exposure recorded by the licensee or registrant (i.e., Item 18 of a previous Form RAD-A); or if the licensee or registrant chooses not to refer to the previous exposure, the whole body dose must be limited to 1.25 rem per quarter.

Item 7. Indicate the method used for monitoring the individual's exposure to each type of radiation to which he is exposed in the course of his duties. Abbreviations may be used.

Item 8. The period of exposure should specify the day the measurement of that exposure was initiated and the day on which it was terminated. For example, a film badge issued Monday morning, August 4, 1980, and picked up Friday, August 15, 1980, would be indicated as 8/4/80-8/15/80.

Items 9, 10 and 11. Self-explanatory. The values are to be given in rem. All measurements are to be interpreted in the best method known. A description of the method of analyzing the monitoring results in terms of dose is to be maintained in conjunction with these records. In any case where the dose for a calendar quarter is less than 10% of the value specified in *Table 1, Appendix A*, the phrase "less than 10%" may be entered in lieu of a numerical value.

Item 12. Add the values under Items 9, 10 and 11 for each period of exposure and record the total. In calculating the "Total" any entry "less than 10%" may be disregarded.

Item 13. The running total is to be maintained on the basis of calendar quarters.

LIFETIME ACCUMULATED DOSE (whole body)

Note: If the licensee or registrant chooses to keep the individual's exposure below that permitted in *Table 1, Appendix A*, Items 14 through 18 need not be completed. However, in that case the total whole body dose for each calendar quarter recorded in Item 13 should not exceed 1¼ rem as indicated in Item 6. Complete Items 14 through 18 when body of record in full. Values in Column 13, when in the middle of the calendar quarter, and Item 18 must be brought forward to next sheet for each individual.

Item 14. Enter the previous total accumulated dose from previous dose records for the individual (e.g., Item 16 if Form RAD-A.)

Item 15. Enter the sum of all totals under Item 12.

Item 16. Add Item 14 and Item 15 and enter that sum.

Item 17. Obtain the Permissible Accumulated Dose (MPD) in rem for the WHOLE BODY. Use the value for N from Item 4. Subtract 18 from N and multiply the difference by 5 rem (e.g., John Smith, Age 32: N = 32, MPD = 5 (32 -18) = 70 rem).

Item 18. Determine the Permissible Dose by subtracting Item 16 from Item 17. The Permissible Dose is that portion of the Lifetime Accumulated Dose for the individual remaining at the end of the period covered by this sheet.

Item 19. Self-explanatory.

STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX D

Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	3×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-6}	1×10^{-1}	1×10^{-7}	5×10^{-3}
		I	2×10^{-5}	1×10^{-1}	8×10^{-7}	5×10^{-3}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}	—	1×10^{-4}	—
	A 41	Sub	2×10^{-6}	—	4×10^{-8}	—
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-2}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-8}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}

STANDARDS FOR PROTECTION AGAINST RADIATION
APPENDIX D
Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
		I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}
Bromine (35)........	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
		I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd 115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)........	Ca 45	S	3×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98).....	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 251	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 252	S	2×10^{-11}	7×10^{-4}	7×10^{-13}	2×10^{-5}
		I	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
Carbon (6)..........	C 14	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-5}	——	1×10^{-6}	——
Cerium (58).........	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Se 144	S	1×10^{-8}	3×10^{-4}	3×10^{-10}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55).........	Cs 131	S	1×10^{-5}	7×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-2}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)........	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}

STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX D

Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)......		S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-2}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-8}	3×10^{-3}	2×10^{-9}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29).........	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
		I	2×10^{-10}	7×10^{-4}	6×10^{-12}	3×10^{-5}
	Cm 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	5×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm 244	S	9×10^{-12}	2×10^{-4}	3×10^{-12}	7×10^{-3}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm 245	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 246	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 247	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	6×10^{-4}	4×10^{-12}	2×10^{-5}
	Cm 248	S	6×10^{-13}	1×10^{-5}	2×10^{-14}	4×10^{-7}
		I	1×10^{-10}	4×10^{-5}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
		I	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-4}	3×10^{-11}	2×10^{-5}
		I	6×10^{-10}	7×10^{-4}	2×10^{-11}	2×10^{-5}
	Es 254m	S	5×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
		I	6×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
	Es 254	S	2×10^{-11}	4×10^{-4}	6×10^{-13}	1×10^{-5}
		I	1×10^{-10}	4×10^{-4}	4×10^{-12}	1×10^{-5}
	Es 255	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	4×10^{-10}	8×10^{-4}	1×10^{-11}	3×10^{-5}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	(T/2=9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}

STANDARDS FOR PROTECTION AGAINST RADIATION
APPENDIX D
Concentration to Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
	(T/2=13 yrs)	I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-9}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-9}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
Fermium (100)	Fm 254	S	6×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
		I	7×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Fm 255	S	2×10^{-8}	1×10^{-3}	6×10^{-10}	3×10^{-5}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	3×10^{-5}
	Fm 256	S	3×10^{-9}	3×10^{-5}	1×10^{-10}	9×10^{-7}
		I	2×10^{-9}	3×10^{-5}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-4}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Geranium (32)	Ge 71	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Au 199	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-4}
Hafnium (72)	Hf 181	S	4×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
		I	7×10^{-8}	2×10^{-3}	3×10^{-9}	7×10^{-5}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Hydrogen (1)	H 3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		Sub	2×10^{-3}	—	4×10^{-5}	—
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-3}
		I	7×10^{-6}	4×10^{-2}	2×10^{-7}	1×10^{-3}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-5}
		I	3×10^{-8}	3×10^{-3}	1×10^{-9}	9×10^{-5}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	6×10^{-9}	2×10^{-4}
	I 126	S	8×10^{-9}	5×10^{-5}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	I 129	S	2×10^{-9}	1×10^{-5}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}

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APPENDIX D

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Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	I 32	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	I 133	S	3×10^{-8}	2×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-5}
Iodine (53)..........	I 134	I	3×10^{-6}	2×10^{-2}	1×10^{-7}	6×10^{-4}
	I 135	S	1×10^{-7}	7×10^{-4}	1×10^{-9}	4×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-2}	3×10^{-8}	8×10^{-4}
		I	1×10^{-5}	7×10^{-2}	3×10^{-8}	2×10^{-3}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)........	Kr 85m	Sub	6×10^{-6}	—	1×10^{-7}	—
	Kr 85	Sub	1×10^{-5}	—	3×10^{-7}	—
	Kr 87	Sub	1×10^{-6}	—	2×10^{-8}	—
	Kr 88	Sub	1×10^{-6}	—	2×10^{-8}	—
Lanthanum (57).....	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)...........	Pb 203	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-5}	4×10^{-4}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-8}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
Lutetium (71).......	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)........	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-9}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42) ...	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}

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Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-3}	8×10^{-3}	5×10^{-8}	3×10^{-4}
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-2}	3×10^{-8}	2×10^{-3}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-4}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium .... (Columbium)(41)	Nb 93m	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	5×10^{-4}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}

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Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-3}
	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84).......	Po 210	S	5×10^{-10}	2×10^{-5}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59) ..	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91) ..	Pa 230	S	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-12}	3×10^{-5}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}	—	1×10^{-8}	—
	Rn 222	S	1×10^{-7}	—	3×10^{-9}	—
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-2}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}

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Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-5}
	Sm 151	S	6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Scandium (21).......	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-4}
Silver	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11).........	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
		I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Sr 90	S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}

STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX D

Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}
Technetium (43).....	Tc 96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	3×10^{-5}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)........	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 228	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-12}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}

STANDARDS FOR PROTECTION AGAINST RADIATION
APPENDIX D
Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μc/ml)	Water (μc/ml)	Air (μc/ml)	Water (μc/ml)
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	4×10^{-5}
	Th natural	S	3×10^{-11}	3×10^{-5}	1×10^{-12}	1×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)........	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)...............	W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 234	S	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 235	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U 238	S	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
	U natural	S	7×10^{-11}	5×10^{-4}	3×10^{-12}	2×10^{-5}
		I	6×10^{-11}	5×10^{-4}	2×10^{-12}	2×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}	—	4×10^{-7}	—
	Xe 133	Sub	1×10^{-5}	—	3×10^{-7}	—
	Xe 133m	Sub	1×10^{-5}	—	3×10^{-7}	—
	Xe 135	Sub	4×10^{-6}	—	1×10^{-7}	—
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)........	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}

STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX D

Concentration in Air and Water Above Natural Background
(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μc/ml)	Table I Column 2 Water (μc/ml)	Table II Column 1 Air (μc/ml)	Table II Column 2 Water (μc/ml)
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-2}	4×10^{-9}	8×10^{-4}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours...............	......	Sub	1×10^{-6}	.....	3×10^{-8}	.....
Any single radionuclide not listed above, with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours................	......		3×10^{-4}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above which decays by alpha emission or spontaneous fission...	......		6×10^{-13}	4×10^{-7}	2×10^{-14}	3×10^{-8}

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

Note: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix D for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "I" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's, are MPC_A, and MPC_B, and MPC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} \leq 1$$

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix D shall be:

a. For purposes of Table I, Col. 1—6×10^{-12}

b. For purposes of Table I, Col. 2—4×10^{-7}

c. For purposes of Table II, Col. 1—2×10^{-14}

d. For purposes of Table II, Col. 2—3×10^{-8}

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix D for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix D are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix D for any radionuclide which is not known to be absent from the mixture; or

Element (atomic number) and Isotope [1]	Table I		Table II	
	Column 1	Column 2	Column 1	Column 2
	Air (µc/ml)	Water (µc/ml)	Air (µc/ml)	Water (µc/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, Thnat, Cm 248, Cf 254, and Fm 256 are not present	.....	9×10^{-5}	.....	3×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 223, Ra 226, Ra 228, Pa 231, Thnat, Cm 248 Cf 254, and Fm 256 are not present	.....	6×10^{-5}	.....	2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present....	.....	2×10^{-5}	.....	6×10^{-7}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present	.....	3×10^{-4}	.....	1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present	3×10^{-9}	.....	1×10^{-10}	.....
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-10}	.....	1×10^{-11}	.....
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}	.....	1×10^{-12}	.....
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}	.....	1×10^{-13}	.....

4. If the mixture of radionuclides consists of uranium and its daughter products in ore dust prior to chemical processing of the uranium ore, the values specified below may be used in lieu of those determined in accordance with paragraph 1 above or those specified in paragraphs 2 and 3 above.

a. For purposes of Table I, Col. 1—1×10^{-10} μ/ml gross alpha activity; or 2.5×10^{-11} μ/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μc/ml gross alpha activity; or 8×10^{-12} μ/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix D (MPC_A) does not exceed 1/10,

(i.e. $\frac{C_A}{MPC_A} \leq \frac{1}{10}$)

and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed ¼.

(i.e. $\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \ldots\ldots \leq ¼$).

APPENDIX E

EXEMPT QUANTITIES

Material	Microcuries
Americium-241	0.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 (9.2 h)	100
Europium-152 (13 yr)	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000

Indium-113m	100
Indium-114m	10
Indium-155m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	0.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	0.01
Rhenium-186	100
Rhenium-188	100

Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-100m	1
Silver-111	100
Sodium-22	10
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural) 1/	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural) 2/	100
Uranium-233	0.01
Uranium-234	
Uranium-235	0.01
Vanadium-48	10

Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	0.1

APPENDIX F

SUBJECTS TO BE COVERED DURING THE INSTRUCTION OF INDUSTRIAL RADIOGRAPHERS *

I. *Fundamentals of Radiation Safety*
- A. Characteristics of gama and x radiation
- B. Units of radiation dose (mrem) and quantity of radioactivity (curie)
- C. Hazards of excessive exposure of radiation
- D. Levels of radiation from sources of radiation
- E. Methods of controlling radiation dose
  1. Working time
  2. Working distances
  3. Shielding

II. *Radiation Detection Instrumentation to be Used*
- A. Use of radiation survey instruments
  1. Operation
  2. Calibration
  3. Limitations
- B. Survey techniques
- C. Use of personnel monitoring equipment
  1. Film badges
  2. Pocket dosimeters
  3. Pocket chambers
  4. TLD badges

III. *Radiographic Equipment to be Used*
- A. Remote handling equipment
- B. Radiographic exposure devices and sealed sources
- C. Storage containers
- D. Operation and control of x-ray equipment

IV. *The Requirements of Pertinent Federal Regulations and State Rules*

V. *The Person in Control's Written Operating and Emergency Procedures*

* Note: The National Council on Radiation Protection and Measurements, *NCRP Report No. 61, Radiation Safety Training Criteria for Industrial Radiography* (1978) provides a detailed outline for the training of industrial radiographers (See Appendix G).

APPENDIX G

REFERENCES

National Bureau of Standards, Handbook 69

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

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EPA-R4-73-014

Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460

NCRP, 49, 61

National Council on Radiation Protection and Measurements
Publications
P.O. Box 4867
Washington, D.C. 20008

Method 703, *"Gross Alpha and Beta Radioactivity"*
Method 704, *"Total Strontium and Strontium-90 in Water"*
Method 705, *"Radium in Water by Precipitation"*
Method 706, *"Radium-226 by Radon in Water"*
Method 708, *"Tritium in Water"*

American Public Health Association
1015 — 15th Street Northwest
Washington, D.C. 20005
(Standard Methods for the Examination of Water and Wastewater, 15th Edition 1980)

ASTM D-2459, "Gamma Spectrometry in Water"
ASTM D-2907

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

HASL-300

Energy Research and Development Administration
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(HASL Laboratory Procedure Manual by John Harley, 1973)