PART D

APPENDIX B

ANNUAL LIMITS ON INTAKE (ALI) AND DERIVED AIR CONCENTRATIONS (DAC) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SANITARY SEWERAGE

Introduction

For each radionuclide, Table I indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm (micron), and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D if less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. The class (D, W, or Y) given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table I, column 2 and 3. Table II provides concentration limits for airborne and liquid effluents released to the general environment. Table III provides concentration limits for discharges to sanitary sewerage.

Note: The values in Tables I, II, and III are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table I "Occupational Values"

Note that the columns in Table I of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "reference man" which would result in either (1) a committed effective dose equivalent of 0.05 sievert (5 rem), stochastic ALI, or (2) a committed dose equivalent of 0.5 sievert (50 rem) to an organ or tissue, non-stochastic ALI. The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 0.05 sievert (5 rem). The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in D.3. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T = 0.06$ is applicable to each of the 5 organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following portions of the GI tract – stomach, small intestine, upper large intestine, and lower large intestine – are to be treated as 4 separate organs.

Note that the dose equivalents for an extremity, skin and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. Abbreviated organ or tissue designations are used:

LLI wall = lower large intestine wall;
St wall = stomach wall;
Blad wall = bladder wall; and
Bone surf = bone surface.

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 0.5 sievert (50 rem) dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose equivalent to that organ, not the effective dose. For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is, $\sum$ (intake (in μCi) of each radionuclide/ALI_{ns}) <1.0. If there is an external deep dose equivalent contribution of H_d, then this sum must be less than 1 - (H_d/50), instead of < 1.0.

Note that the dose equivalents for an extremity, skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

$$DAC = ALI(\text{in } \mu Ci)/(2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI/2.4 \times 10^9] \ \mu Ci/ml,$$

where 2×10^4 ml is the volume of air breathed per minute at work by reference man under working conditions of light work.

The DAC values relate to 1 of 2 modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. DACs based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values include contributions to exposure by the single radionuclide named and any in-growth of daughter radionuclides produced in the body by decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The values of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external irradiation. See D.1202. When an individual is exposed to radioactive materials which fall under several of the translocation classifications of the same radionuclide, such as, Class D, Class W, or Class Y, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radionuclides. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table II "Effluent Concentrations"

The columns in Table II of this appendix captioned "Effluents," "Air" and "Water" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of D.1302. The concentration values given in Columns 1 and 2 of Table II are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.5 millisievert (0.05 rem).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at or below the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table II. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in Appendix A of Part D of the eighth edition of Volume I of the *Suggested State Regulations for Control of Radiation.*

The air concentration values listed in Table II, Column 1 were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 (ml), relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 0.05 sievert (5 rem) annual occupational dose limit to the 1 millisievert (0.1 rem) limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

For those radionuclides for which submersion, that is external dose, is limiting, the occupational DAC in Table I, Column 3 was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7. The factor of 7.3×10^7 ml includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 ml which is the annual water intake of reference man.

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings, including occupational inhalation ALIs and DACs, air and water effluent concentrations and releases to sewer, require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

Table III "Releases to Sewers"

The monthly average concentrations for release to sanitary sewerage are applicable to the provisions in D.2003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 ml. The factor of 7.3×10^6 ml is composed of a factor of 7.3×10^5 ml, the annual water intake by reference man, and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 5 millisievert (0.5 rem).

List of Elements

Name	Symbol	Atomic Number	Name	Symbol	Atomic Number
Actinium	Ac	89	Chromium	Cr	24
Aluminum	Al	13	Cobalt	Co	27
Americium	Am	95	Copper	Cu	29
Antimony	Sb	51	Curium	Cm	96
Argon	Ar	18	Dysprosium	Dy	66
Arsenic	As	33	Einsteinium	Es	99
Astatine	At	85	Erbium	Er	68
Barium	Ba	56	Europium	Eu	63
Berkelium	Bk	97	Fermium	Fm	100
Beryllium	Be	4	Fluorine	F	9
Bismuth	Bi	83	Francium	Fr	87
Bromine	Br	35	Gadolinium	Gd	64
Cadmium	Cd	48	Gallium	Ga	31
Calcium	Ca	20	Germanium	Ge	32
Californium	Cf	98	Gold	Au	79
Carbon	C	6	Hafnium	Hf	72
Cerium	Ce	58	Holmium	Ho	67
Cesium	Cs	55	Hydrogen	H	1
Chlorine	Cl	17	Indium	In	49

List of Elements *(Continued)*

Name	Symbol	Atomic Number	Name	Symbol	Atomic Number
Iodine	I	53	Technetium	Tc	43
Iridium	Ir	77	Tellurium	Te	52
Iron	Fe	26	Terbium	Tb	65
Krypton	Kr	36	Thallium	Tl	81
Lanthanum	La	57	Thorium	Th	90
Lead	Pb	82	Thulium	Tm	69
Lutetium	Lu	71	Tin	Sn	50
Magnesium	Mg	12	Titanium	Ti	22
Manganese	Mn	25	Tungsten	W	74
Mendelevium	Md	101	Uranium	U	92
Mercury	Hg	80	Vanadium	V	23
Molybdenum	Mo	42	Xenon	Xe	54
Neodymium	Nd	60	Ytterbium	Yb	70
Neptunium	Np	93	Yttrium	Y	39
Nickel	Ni	28	Zinc	Zn	30
Niobium	Nb	41	Zirconium	Zr	40
Osmium	Os	76			
Palladium	Pd	46			
Phosphorus	P	15			
Platinum	Pt	78			
Plutonium	Pu	94			
Polonium	Po	84			
Potassium	K	19			
Praseodymium	Pr	59			
Promethium	Pm	61			
Protactinium	Pa	91			
Radium	Ra	88			
Radon	Rn	86			
Rhenium	Re	75			
Rhodium	Rh	45			
Rubidium	Rb	37			
Ruthenium	Ru	44			
Samarium	Sm	62			
Scandium	Sc	21			
Selenium	Se	34			
Silicon	Si	14			
Silver	Ag	47			
Sodium	Na	11			
Strontium	Sr	38			
Sulfur	S	16			
Tantalum	Ta	73			

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2) Submersion[a]: Use above values as HT and T_2 oxidize in air and in the body to HTO.						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	–	2E+4	8E-6	3E-8	–	–
4	Beryllium-10	W, see ^{7}Be	1E+3	2E+2	6E-8	2E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{7}Be	–	1E+1	6E-9	2E-11	–	–
6	Carbon-11[b]	Monoxide	–	1E+6	5E-4	2E-6	–	–
		Dioxide	–	6E+5	3E-4	9E-7	–	–
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	–	2E+6	7E-4	2E-6	–	–
		Dioxide	–	2E+5	9E-5	3E-7	–	–
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
9	Fluorine-18[b]	D, fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4	7E+4	3E-5	1E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re	–	9E+4	4E-5	1E-7	–	–
		Y, lanthanum fluoride	–	8E+4	3E-5	1E-7	–	–
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	1E+3	5E-7	2E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	9E+1	4E-8	1E-10	–	–
14	Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and nitrates	–	3E+4	1E-5	5E-8	–	–
		Y, aluminosilicate glass	–	3E+4	1E-5	4E-8	–	–
14	Silicon-32	D, see ^{31}Si	2E+3	2E+2	1E-7	3E-10	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		W, see ^{31}Si	–	1E+2	5E-8	2E-10	–	–
		Y, see ^{31}Si	–	5E+0	2E-9	7E-12	–	–
15	Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
		W, phosphates of Zn^{2+}, S^{3+}, Mg^{2+}, Fe^{3+}, Bi^{3+}, and lanthanides	–	4E+2	2E-7	5E-10	–	–
15	Phosphorus-33	D, see ^{32}P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
		W, see ^{32}P	–	3E+3	1E-6	4E-9	–	–
16	Sulfur-35	Vapor	–	1E+4	6E-6	2E-8	–	–
		D, sulfides and sulfates except those given for W	1E+4	2E+4	7E-6	2E-8	–	–
			LLI wall (8E+3)	–	–	–	1E-4	1E-3
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	6E+3 –	2E+3	9E-7	3E-9	–	–
17	Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	–	2E+2	1E-7	3E-10	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
17	Chlorine-38[b/]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	–	–
			St wall (3E+4)	–	–	–	3E-4	3E-3
		W, see ^{36}Cl	–	5E+4	2E-5	6E-8	–	–
17	Chlorine-39[b/]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{36}Cl	–	6E+4	2E-5	8E-8	–	–
18	Argon-37	Submersion[a/]	–	–	1E+0	6E-3	–	–
18	Argon-39	Submersion[a/]	–	–	2E-4	8E-7	–	–
18	Argon-41	Submersion[a/]	–	–	3E-6	1E-8	–	–
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[b/]	D, all compounds	2E+4	7E+4	3E-5	9E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
19	Potassium-45[b/]	D, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	–	–	–
			Bone surf (4E+3)	Bone surf (4E+3)	–	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
21	Scandium-49[b/]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	3E+1	1E-8	4E-11	–	–
		Y, SrTi0	–	6E+0	2E-9	8E-12	–	–
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{44}Ti	–	4E+4	1E-5	5E-8	–	–
		Y, see ^{44}Ti	–	3E+4	1E-5	4E-8	–	–
23	Vanadium-47[b/]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	–	1E+5	4E-5	1E-7	–	–
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	–	6E+2	3E-7	9E-10	–	–
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	–	–	–
			LLI wall (9E+4)	Bone surf (3E+4)	–	5E-8	1E-3	1E-2
		W, see ^{47}V	–	2E+4	8E-6	2E-8	–	–
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	–	7E+3	3E-6	1E-8	–	–
		Y, oxides and hydroxides	–	7E+3	3E-6	1E-8	–	–
24	Chromium-49[b/]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	–	1E+5	4E-5	1E-7	–	–
		Y, see ^{48}Cr	–	9E+4	4E-5	1E-7	–	–
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{48}Cr	–	2E+4	8E-6	3E-8	–	–
25	Manganese-51[b/]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	–	6E+4	3E-5	8E-8	–	–
25	Manganese-52m[b/]	D, see ^{51}Mn	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{51}Mn	–	1E+5	4E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
25	Manganese-52	D, see ^{51}Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
		W, see ^{51}Mn	–	9E+2	4E-7	1E-9	–	–
25	Manganese-53	D, see ^{51}Mn	5E+4	1E+4	5E-6	–	7E-4	7E-3
			–	Bone surf (2E+4)	-	3E-8	–	–
		W, see ^{51}Mn	–	1E+4	5E-6	2E-8	–	–
25	Manganese-54	D, see ^{51}Mn	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see ^{51}Mn	–	8E+2	3E-7	1E-9	–	–
25	Manganese-56	D, see ^{51}Mn	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{51}Mn	–	2E+4	9E-6	3E-8	–	–
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	–	2E+3	1E-6	3E-9	–	–
26	Iron-55	D, see ^{52}Fe	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see ^{52}Fe	–	4E+3	2E-6	6E-9	–	–
26	Iron-59	D, see ^{52}Fe	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see ^{52}Fe	–	2E-7	7E-10	–	–	–
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see ^{52}Fe	-1	8E-9	3E-11	–	–	–
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	–	E+3	1E-6	4E-9	–	–
27	Cobalt-56	W, see ^{55}Co	5E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	4E+2	2E+2	8E-8	3E-10	–	–
27	Cobalt-57	W, see ^{55}Co	8E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	4E+3	7E+2	3E-7	9E-10	–	–
27	Cobalt-58m	W, see ^{55}Co	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see ^{55}Co	–	6E+4	3E-5	9E-8	–	–
27	Cobalt-58	W, see ^{55}Co	2E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see ^{55}Co	1E+3	7E+2	3E-7	1E-9	–	–
27	Cobalt-60m[b/]	W, see ^{55}Co	1E+6 St wall (1E+6)	4E+6	2E-3	6E-6	–	–
		Y, see ^{55}Co	–	3E+6	1E-3	4E-6	2E-2 –	2E-1 –

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
27	Cobalt-60	W, see ^{55}Co	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	1E-8	5E-11	–	–
27	Cobalt-61[b/]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+4	6E+4	2E-5	8E-8	–	–
27	Cobalt-62m[b/]	W, see ^{55}Co	4E+4	2E+5	7E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{55}Co	–	2E+5	6E-5	2E-7	–	–
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	–	1E+3	5E-7	2E-9	–	–
		Vapor	–	1E+3	5E-7	2E-9	–	–
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	6E+3	3E-6	9E-9	–	–
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	–	7E+3	3E-6	1E-8	–	–
		Vapor	–	2E+3	8E-7	3E-9	–	–
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	8E+2	3E-7	1E-9	–	–
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	–	3E+4	1E-5	4E-8	–	–
		Vapor	–	2E+4	7E-6	2E-8	–	–
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{56}Ni	–	6E+2	3E-7	9E-10	–	–
		Vapor	–	3E+3	1E-6	4E-9	–	–
29	Copper-60[b/]	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, sulfides, halides, and nitrates	–	1E+5	5E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	4E-5	1E-7	–	–
29	Copper-61	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	4E+4	2E-5	6E-8	–	–
		Y, see ^{60}Cu	–	4E+4	1E-5	5E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
29	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{60}Cu	–	2E+4	9E-6	3E-8	–	–
29	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	–	5E+3	2E-6	7E-9	–	–
		Y, see ^{60}Cu	–	5E+3	2E-6	6E-9	–	–
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[b/]	Y, all compounds	2E+4 St wall (3E+4)	7E+4	3E-5	9E-8	–	–
				–	–	–	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69[b/]	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
30	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65[b/]	D, all compounds except those given for W	5E+4 St wall (6E+4)	2E+5	7E-5	2E-7	–	–
				–	–	–	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	–	2E+5	8E-5	3E-7	–	–
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	–	1E+4	4E-6	1E-8	–	–
31	Gallium-68[b/]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	–	5E+4	2E-5	7E-8	–	–
31	Gallium-70[b/]	D, see ^{65}Ga	5E+4 St wall (7E+4)	2E+5	7E-5	2E-7	–	–
				–	–	–	1E-3	1E-2
		W, see ^{65}Ga	–	2E+5	8E-5	3E-7	–	–
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	–	2E+4	6E-6	2E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	–	2E+4	8E-6	3E-8	–	–
32	Germanium-67[b/]	D, see ^{66}Ge	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, see ^{66}Ge	–	1E+5	4E-5	1E-7	–	–
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	–	1E+2	4E-8	1E-10	–	–
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	–	8E+3	3E-6	1E-8	–	–
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	–	4E+4	2E-5	6E-8	–	–
32	Germanium-75[b/]	D, see ^{66}Ge	4E+4	8E+4	3E-5	1E-7	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{66}Ge	–	8E+4	4E-5	1E-7	–	–
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	–	6E+3	2E-6	8E-9	–	–
32	Germanium-78[b/]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	–	–
			St wall (2E+4)	–	–	–	3E-4	3E-3
		W, see ^{66}Ge	–	2E+4	9E-6	3E-8	–	–
33	Arsenic-69[b/]	W, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
33	Arsenic-70[b/]	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33	Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33	Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33	Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	6E-5	6E-4
33	Arsenic-78[b/]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[b/]	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	1E+4	4E+4	2E-5	6E-8	–	–
34	Selenium-73m[b/]	D, see ^{70}Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	6E-5	2E-7	–	–
34	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	–	2E+4	7E-6	2E-8	–	–
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	–	6E+2	3E-7	8E-10	–	–
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	–	6E+2	2E-7	8E-10	–	–
34	Selenium-81m[b/]	D, see ^{70}Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	2E+4	7E+4	3E-5	1E-7	–	–
34	Selenium-81[b/]	D, see ^{70}Se	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		W, see ^{70}Se	–	2E+5	1E-4	3E-7	-	-
34	Selenium-83[b/]	D, see ^{70}Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	–	–
35	Bromine-74m[b/]	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	–	–
			St wall (2E+4)	–	–	–	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	–	4E+4	2E-5	6E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage (*Continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
35	Bromine-74[b/]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	8E+4	4E-5	1E-7	–	–
35	Bromine-75[b/]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	5E+4	2E-5	7E-8	–	–
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	–	4E+3	2E-6	6E-9	–	–
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	–	2E+4	8E-6	3E-8	–	–
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	–	1E+4	6E-6	2E-8	–	–
35	Bromine-80[b/]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{74m}Br	–	2E+5	9E-5	3E-7	–	–
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	–	4E+3	2E-6	5E-9	–	–
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
35	Bromine-84[b/]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
36	Krypton-74[b/]	Submersion[a/]	–	–	3E-6	1E-8	–	–
36	Krypton-76	Submersion[a/]	–	–	9E-6	4E-8	–	–
36	Krypton-77[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
36	Krypton-79	Submersion[a/]	–	–	2E-5	7E-8	–	–
36	Krypton-81	Submersion[a/]	–	–	7E-4	3E-6	–	–
36	Krypton-83m[b/]	Submersion[a/]	–	–	1E-2	5E-5	–	–
36	Krypton-85m	Submersion[a/]	–	–	2E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
36	Krypton-85	Submersion[a]	–	–	1E-4	7E-7	–	–
36	Krypton-87[b]	Submersion[a]	–	–	5E-6	2E-8	–	–
36	Krypton-88	Submersion[a]	–	–	2E-6	9E-9	–	–
37	Rubidium-79[b]	D, all compounds	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
37	Rubidium-81m[b]	D, all compounds	2E+5	3E+5	1E-4	5E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88[b]	D, all compounds	2E+4	6E+4	3E-5	9E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
37	Rubidium-89[b]	D, all compounds	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
38	Strontium-80[b]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTi0_3$	–	1E+4	5E-6	2E-8	–	–
38	Strontium-81[b]	D, see ^{80}Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{80}Sr	2E+4	8E+4	3E-5	1E-7	–	–
38	Strontium-82	D, see ^{80}Sr	3E+2	4E+2	2E-7	6E-10	–	–
			LLI wall (2E+2)	–	–	–	3E-6	3E-5
		Y, see ^{80}Sr	2E+2	9E+1	4E-8	1E-10	–	–
38	Strontium-83	D, see ^{80}Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{80}Sr	2E+3	4E+3	1E-6	5E-9	–	–
38	Strontium-85m[b]	D, see ^{80}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{80}Sr	–	8E+5	4E-4	1E-6	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
38	Strontium-85	D, see ^{80}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{80}Sr	–	2E+3	6E-7	2E-9	–	–
38	Strontium-87m	D, see ^{80}Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{80}Sr	4E+4	2E+5	6E-5	2E-7	–	–
38	Strontium-89	D, see ^{80}Sr	6E+2	8E+2	4E-7	1E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{80}Sr	5E+2	1E+2	6E-8	2E-10	–	–
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	–	–	–
			Bone surf (4E+1)	Bone surf (2E+1)	–	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	–	4E+0	2E-9	6E-12	–	–
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	–	4E+3	1E-6	5E-9	–	–
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	–	7E+3	3E-6	9E-9	–	–
39	Yttrium-86m[b/]	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	–	5E+4	2E-5	8E-8	–	–
39	Yttrium-86	W, see ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	–	2E+2	1E-7	3E-10	–	–
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	–	1E+4	5E-6	2E-8	–	–
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{86m}Y	–	6E+2	3E-7	9E-10	–	–
39	Yttrium-91m[b/]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	–	2E+5	7E-5	2E-7	–	–
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{86m}Y	–	1E+2	5E-8	2E-10	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	–	8E+3	3E-6	1E-8	–	–
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	2E+3	1E-6	3E-9	–	–
39	Yttrium-94[b/]	W, see ^{86m}Y	2E+4	8E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		Y, see ^{86m}Y	–	8E+4	3E-5	1E-7	–	–
39	Yttrium-95[b/]	W, see ^{86m}Y	4E+4	2E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{86m}Y	–	1E+5	6E-5	2E-7	–	–
40	Zirconium-86	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, oxides, hydroxides, halides, and nitrates	–	3E+3	1E-6	4E-9	–	–
		Y, carbide	–	2E+3	1E-6	3E-9	–	–
40	Zirconium-88	D, see ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	–	5E+2	2E-7	7E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
		Y, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
40	Zirconium-93	D, see ^{86}Zr	1E+3	6E+0	3E-9	–	–	–
			Bone surf (3E+3)	Bone surf (2E+1)	–	2E-11	4E-5	4E-4
		W, see ^{86}Zr	–	2E+1	1E-8	–	–	–
			–	Bone surf (6E+1)	–	9E-11	–	–
		Y, see ^{86}Zr	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	9E-11	–	–
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2	5E-8	–	2E-5	2E-4
			–	Bone surf (3E+2)	–	4E-10	–	–
		W, see ^{86}Zr	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
		W, see ^{86}Zr	–	1E+3	6E-7	2E-9	–	–
		Y, see ^{86}Zr	–	1E+3	5E-7	2E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
41	Niobium-88[b/]	W, all compounds except those given for Y	5E+4	2E+5	9E-5	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides and hydroxides	–	2E+5	9E-5	3E-7	–	–
41	Niobium-89[b/] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	–	4E+4	2E-5	5E-8	–	–
41	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	–	2E+4	6E-6	2E-8	–	–
41	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-93m	W, see ^{88}Nb	9E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+4)	–	–	–	2E-4	2E-3
		Y, see ^{88}Nb	–	2E+2	7E-8	2E-10	–	–
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+1	6E-9	2E-11	–	–
41	Niobium-95m	W, see ^{88}Nb	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{88}Nb	–	2E+3	9E-7	3E-9	–	–
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	–	1E+3	5E-7	2E-9	–	–
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-97[b/]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	–	7E+4	3E-5	1E-7	–	–
41	Niobium-98[b/]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	–	5E+4	2E-5	7E-8	–	–
42	Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	2E+3	5E+3	2E-6	6E-9	–	–
42	Molybdenum-93m	D, see ^{90}Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	4E+3	1E+4	6E-6	2E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	2E+4	2E+2	8E-8	2E-10	–	–
42	Molybdenum-99	D, see ^{90}Mo	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{90}Mo	1E+3	1E+3	6E-7	2E-9	–	–
42	Molybdenum-101[b/]	D, see ^{90}Mo	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{90}Mo	–	1E+5	6E-5	2E-7	–	–
43	Technetium-93m[b/]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	–	3E+5	1E-4	4E-7	–	–
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	–	1E+5	4E-5	1E-7	–	–
43	Technetium-94m[b/]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	–	6E+4	2E-5	8E-8	–	–
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	1E-5	3E-8	–	–
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	–	2E+3	8E-7	3E-9	–	–
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	8E-6	3E-8	–	–
43	Technetium-96m[b/]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	–	2E+3	9E-7	3E-9	–	–
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3	3E-6	–	6E-5	6E-4
			–	St wall (7E+3)	–	1E-8	–	–
		W, see ^{93m}Tc	–	1E+3	5E-7	2E-9	–	–
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	–	6E+3	2E-6	8E-9	–	–
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	–	3E+2	1E-7	4E-10	–	–
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
43	Technetium-99	D, see ^{93m}Tc	4E+3	5E+3	2E-6	–	6E-5	6E-4
				St wall (6E+3)	–	8E-9	–	–
		W, see ^{93m}Tc	–	7E+2	3E-7	9E-10	–	–
43	Technetium-101[b/]	D, see ^{93m}Tc	9E+4	3E+5	1E-4	5E-7	–	–
			St wall (1E+5)	–	–	–	2E-3	2E-2
		W, see ^{93m}Tc	–	4E+5	2E-4	5E-7	–	–
43	Technetium-104[b/]	D, see ^{93m}Tc	2E+4	7E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{93m}Tc	–	9E+4	4E-5	1E-7	–	–
44	Ruthenium-94[b/]	D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	–	6E+4	3E-5	9E-8	–	–
		Y, oxides and hydroxides	–	6E+4	2E-5	8E-8	–	–
44	Ruthenium-97	D, see ^{94}Ru	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
		Y, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
44	Ruthenium-103	D, see ^{94}Ru	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see ^{94}Ru	–	1E+3	4E-7	1E-9	–	–
		Y, see ^{94}Ru	–	6E+2	3E-7	9E-10	–	–
44	Ruthenium-105	D, see ^{94}Ru	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{94}Ru	–	1E+4	6E-6	2E-8	–	–
		Y, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
44	Ruthenium-106	D, see ^{94}Ru	2E+2	9E+1	4E-8	1E-10	–	–
			LLI wall (2E+2)	–	–	–	3E-6	3E-5
		W, see ^{94}Ru	–	5E+1	2E-8	8E-11	–	–
		Y, see ^{94}Ru	–	1E+1	5E-9	2E-11	–	–
45	Rhodium-99m	D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		W, halides	–	8E+4	3E-5	1E-7	–	–
		Y, oxides and hydroxides	–	7E+4	3E-5	9E-8	–	–
45	Rhodium-99	D, see ^{99m}Rh	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{99m}Rh	–	2E+3	9E-7	3E-9	–	–
		Y, see ^{99m}Rh	–	2E+3	8E-7	3E-9	–	–
45	Rhodium-100	D, see ^{99m}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{99m}Rh	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{99m}Rh	–	4E+3	2E-6	5E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	–	8E+3	4E-6	1E-8	–	–
		Y, see ^{99m}Rh	–	8E+3	3E-6	1E-8	–	–
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{99m}Rh	–	2E+2	6E-8	2E-10	–	–
45	Rhodium-102m	D, see ^{99m}Rh	1E+3	5E+2	2E-7	7E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		W, see ^{99m}Rh	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{99m}Rh	–	1E+2	5E-8	2E-10	–	–
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{99m}Rh	–	6E+1	2E-8	8E-11	–	–
45	Rhodium-103m[b/]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
		Y, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
45	Rhodium-105	D, see ^{99m}Rh	4E+3	1E+4	5E-6	2E-8	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{99m}Rh	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{99m}Rh	–	6E+3	2E-6	8E-9	–	–
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	–	4E+4	2E-5	5E-8	–	–
		Y, see ^{99m}Rh	–	4E+4	1E-5	5E-8	–	–
45	Rhodium-107[b/]	D, see ^{99m}Rh	7E+4	2E+5	1E-4	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{99m}Rh	–	3E+5	1E-4	4E-7	–	–
		Y, see ^{99m}Rh	–	3E+5	1E-4	3E-7	–	–
46	Palladium-100	D, all compound44s except those given for W and4 Y	1E+3	1E+3	6E-7	2E-9	2E-5	2E-4
		W, nitrates	–	1E+3	5E-7	2E-9	–	–
		Y, oxides and hydroxides	–	1E+3	6E-7	2E-9	–	–
46	Palladium-101	D, see ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{100}Pd	–	3E+4	1E-5	4E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
46	Palladium-103	D, see ^{100}Pd	6E+3	6E+3	3E-6	9E-9	–	–
			LLI wall (7E+3)	–	–	–	1E-4	1E-3
		W, see ^{100}Pd	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{100}Pd	–	4E+3	1E-6	5E-9	–	–
46	Palladium-107	D, see ^{100}Pd	3E+4	2E+4	9E-6	–	–	–
			LLI wall (4E+4)	Kidneys (2E+4)	–	3E-8	5E-4	5E-3
		W, see ^{100}Pd	–	7E+3	3E-6	1E-8	–	–
		Y, see ^{100}Pd	–	4E+2	2E-7	6E-10	–	–
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	–	5E+3	2E-6	8E-9	–	–
		Y, see ^{100}Pd	–	5E+3	2E-6	6E-9	–	–
47	Silver-102[b/]	D, all compounds except those given for W and Y	5E+4	2E+5	8E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
		W, nitrates and sulfides	–	2E+5	9E-5	3E-7	–	–
		Y, oxides and hydroxides	–	2E+5	8E-5	3E-7	–	–
47	Silver-103[b/]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104m[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104[b/]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-106[b/]	D, see ^{102}Ag	6E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
		W, see ^{102}Ag	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{102}Ag	–	2E+5	8E-5	3E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	–	3E+2	1E-7	4E-10	–	–
		Y, see ^{102}Ag	–	2E+1	1E-8	3E-11	–	–
47	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	–	2E+2	8E-8	3E-10	–	–
		Y, see ^{102}Ag	–	9E+1	4E-8	1E-10	–	–
47	Silver-111	D, see ^{102}Ag	9E+2	2E+3	6E-7	–	–	–
			LLI wall (1E+3)	Liver (2E+3)	–	2E-9	2E-5	2E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	–	1E+4	4E-6	1E-8	–	–
		Y, see ^{102}Ag	–	9E+3	4E-6	1E-8	–	–
47	Silver-115[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{102}Ag	–	9E+4	4E-5	1E-7	–	–
		Y, see ^{102}Ag	–	8E+4	3E-5	1E-7	–	–
48	Cadmium-104[b/]	D, all compounds except those given for W and Y	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, sulfides, halides, and nitrates	–	1E+5	5E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	5E-5	2E-7	–	–
48	Cadmium-107	D, see ^{104}Cd	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{104}Cd	–	6E+4	2E-5	8E-8	–	–
		Y, see ^{104}Cd	–	5E+4	2E-5	7E-8	–	–
48	Cadmium-109	D, see ^{104}Cd	3E+2	4E+1	1E-8	–	–	–
			Kidneys (4E+2)	Kidneys (5E+1)	–	7E-11	6E-6	6E-5
		W, see ^{104}Cd	–	1E+2	5E-8	–	–	–
			–	Kidneys (1E+2)	–	2E-10	–	–
		Y, see ^{104}Cd	–	1E+2	5E-8	2E-10	–	–
48	Cadmium-113m	D, see ^{104}Cd	2E+1	2E+0	1E-9	–	–	–
			Kidneys (4E+1)	Kidneys (4E+0)	–	5E-12	5E-7	5E-6
		W, see ^{104}Cd	–	8E+0	4E-9	–	–	–
			–	Kidneys (1E+1)	–	2E-11	–	–
		Y, see ^{104}Cd	–	1E+1	5E-9	2E-11	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
48	Cadmium-113	D, see ^{104}Cd	2E+1 Kidneys (3E+1)	2E+0 Kidneys (3E+0)	9E-10 –	– 5E-12	– 4E-7	– 4E-6
		W, see ^{104}Cd	– –	8E+0 Kidneys (1E+1)	3E-9 –	– 2E-11	– –	– –
		Y, see ^{104}Cd	–	1E+1	6E-9	2E-11	–	–
48	Cadmium-115m	D, see ^{104}Cd	3E+2 –	5E+1 Kidneys (8E+1)	2E-8 –	– 1E-10	4E-6 –	4E-5 –
		W, see ^{104}Cd	–	1E+2	5E-8	2E-10	–	–
		Y, see ^{104}Cd	–	1E+2	6E-8	2E-10	–	–
48	Cadmium-115	D, see ^{104}Cd	9E+2 LLI wall (1E+3)	1E+3 –	6E-7 –	2E-9 –	– 1E-5	– 1E-4
		W, see ^{104}Cd	–	1E+3	5E-7	2E-9	–	–
		Y, see ^{104}Cd	–	1E+3	6E-7	2E-9	–	–
48	Cadmium-117m	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	–	2E+4	7E-6	2E-8	–	–
		Y, see ^{104}Cd	–	1E+4	6E-6	2E-8	–	–
48	Cadmium-117	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	–	2E+4	7E-6	2E-8	–	–
		Y, see ^{104}Cd	–	1E+4	6E-6	2E-8	–	–
49	Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	–	6E+4	3E-5	9E-8	–	–
49	Indium-110[b] (69.1 min)	D, see ^{109}In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	–	6E+4	2E-5	8E-8	–	–
49	Indium-110 (4.9 h)	D, see ^{109}In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		W, see ^{109}In	–	2E+4	8E-6	3E-8	–	–
49	Indium-111	D, see ^{109}In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4
		W, see ^{109}In	–	6E+3	3E-6	9E-9	–	–
49	Indium-112[b]	D, see ^{109}In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2
		W, see ^{109}In	–	7E+5	3E-4	1E-6	–	–
49	Indium-113m[b]	D, see ^{109}In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		W, see ^{109}In	–	2E+5	8E-5	3E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
49	Indium-114m	D, see ^{109}In	3E+2	6E+1	3E-8	9E-11	–	–
			LLI wall (4E+2)	–	–	–	5E-6	5E-5
		W, see ^{109}In	–	1E+2	4E-8	1E-10	–	–
49	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	–	5E+4	2E-5	7E-8	–	–
49	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	–	5E+0	2E-9	8E-12	–	–
49	Indium-116m[b/]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	–	1E+5	5E-5	2E-7	–	–
49	Indium-117m[b/]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	–	4E+4	2E-5	6E-8	–	–
49	Indium-117[b/]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	–	2E+5	9E-5	3E-7	–	–
49	Indium-119m[b/]	D, see ^{109}In	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		W, see ^{109}In	–	1E+5	6E-5	2E-7	–	–
50	Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	–	1E+4	5E-6	2E-8	–	–
50	Tin-111[b/]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	–	3E+5	1E-4	4E-7	–	–
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	–	–	–
			LLI wall (2E+3)	Bone surf (2E+3)	–	3E-9	3E-5	3E-4
		W, see ^{110}Sn	–	1E+3	6E-7	2E-9	–	–
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{110}Sn	–	1E+3	4E-7	1E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	–	–
			LLI wall (6E+3)	–	–	–	8E-5	8E-4
		W, see ^{110}Sn	–	1E+4	5E-6	2E-8	–	–
50	Tin-123m[b]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	–	1E+5	6E-5	2E-7	–	–
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	–	–
			LLI wall (6E+2)	–	–	–	9E-6	9E-5
		W, see ^{110}Sn	–	2E+2	7E-8	2E-10	–	–
50	Tin-125	D, see ^{110}Sn	4E+2	9E+2	4E-7	1E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{110}Sn	–	4E+2	1E-7	5E-10	–	–
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	–	7E+1	3E-8	9E-11	–	–
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	–	2E+4	8E-6	3E-8	–	–
50	Tin-128[b]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	–	4E+4	1E-5	5E-8	–	–
51	Antimony-115[b]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	–	3E+5	1E-4	4E-7	–	–
51	Antimony-116m[b]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	–	1E+5	6E-5	2E-7	–	–
51	Antimony-116[b]	D, see ^{115}Sb	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{115}Sb	–	3E+5	1E-4	5E-7	–	–
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	–	3E+5	1E-4	4E-7	–	–
51	Antimony-118m	D, see ^{115}Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	5E+3	2E+4	9E-6	3E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
51	Antimony-119	D, see ^{115}Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	2E+4	3E+4	1E-5	4E-8	–	–
51	Antimony-120[b/] (16 min)	D, see ^{115}Sb	1E+5 St wall (2E+5)	4E+5 –	2E-4 –	6E-7 –	– 2E-3	– 2E-2
		W, see ^{115}Sb	–	5E+5	2E-4	7E-7	–	–
51	Antimony-120 (5.76 d)	D, see ^{115}Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	9E+2	1E+3	5E-7	2E-9	–	–
51	Antimony-122	D, see ^{115}Sb	8E+2 LLI wall (8E+2)	2E+3 –	1E-6 –	3E-9 –	– 1E-5	– 1E-4
		W, see ^{115}Sb	7E+2	1E+3	4E-7	2E-9	–	–
51	Antimony-124m[b/]	D, see ^{115}Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	2E+5	6E+5	2E-4	8E-7	–	–
51	Antimony-124	D, see ^{115}Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	2E+2	1E-7	3E-10	–	–
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	–	5E+2	2E-7	7E-10	–	–
51	Antimony-126m[b/]	D, see ^{115}Sb	5E+4 St wall (7E+4)	2E+5 –	8E-5 –	3E-7 –	– 9E-4	– 9E-3
		W, see ^{115}Sb	–	2E+5	8E-5	3E-7	–	–
51	Antimony-126	D, see ^{115}Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	5E+2	2E-7	7E-10	–	–
51	Antimony-127	D, see ^{115}Sb	8E+2 LLI wall (8E+2)	2E+3 –	9E-7 –	3E-9 –	– 1E-5	– 1E-4
		W, see ^{115}Sb	7E+2	9E+2	4E-7	1E-9	–	–
51	Antimony-128[b/] (10.4 min)	D, see ^{115}Sb	8E+4 St wall (1E+5)	4E+5 –	2E-4 –	5E-7 –	– 1E-3	– 1E-2
		W, see ^{115}Sb	–	4E+5	2E-4	6E-7	–	–
51	Antimony-128 (9.01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	–	3E+3	1E-6	5E-9	–	–
51	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	–	9E+3	4E-6	1E-8	–	–
51	Antimony-130[b/]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	–	8E+4	3E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values Col. 2 Inhalation ALI (µCi)	Table I Occupational Values Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations Col. 1 Air (µCi/ml)	Table II Effluent Concentrations Col. 2 Water (µCi/ml)	Table III Releases to Sewers Monthly Average Concentration (µCi/ml)
51	Antimony-131[b/]	D, see ^{115}Sb	1E+4	2E+4	1E-5	–	–	–
			Thyroid (2E+4)	Thyroid (4E+4)	–	6E-8	2E-4	2E-3
		W, see ^{115}Sb	-	2E+4	1E-5	–	–	–
			-	Thyroid (4E+4)	–	6E-8	–	–
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	–	–
52	Tellurium-121m	D, see ^{116}Te	5E+2	2E+2	8E-8	–	–	–
			Bone surf (7E+2)	Bone surf (4E+2)	–	5E-10	1E-5	1E-4
		W, see ^{116}Te	–	4E+2	2E-7	6E-10	–	–
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	–	3E+3	1E-6	4E-9	–	–
52	Tellurium-123m	D, see ^{116}Te	6E+2	2E+2	9E-8	–	–	–
			Bone surf (1E+3)	Bone surf (5E+2)	–	8E-10	1E-5	1E-4
		W, see ^{116}Te	–	5E+2	2E-7	8E-10	–	–
52	Tellurium-123	D, see ^{116}Te	5E+2	2E+2	8E-8	–	–	–
			Bone surf (1E+3)	Bone surf (5E+2)	–	7E-10	2E-5	2E-4
		W, see ^{116}Te	–	4E+2	2E-7	–	–	–
			–	Bone surf (1E+3)	–	2E-9	–	–
52	Tellurium-125m	D, see ^{116}Te	1E+3	4E+2	2E-7	–	–	–
			Bone surf (1E+3)	Bone surf (1E+3)	–	1E-9	2E-5	2E-4
		W, see ^{116}Te	–	7E+2	3E-7	1E-9	–	–
52	Tellurium-127m	D, see ^{116}Te	6E+2	3E+2	1E-7	–	9E-6	9E-5
			–	Bone surf (4E+2)	–	6E-10	–	–
		W, see ^{116}Te	–	3E+2	1E-7	4E-10	–	–
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	–	2E+4	7E-6	2E-8	–	–
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	–	2E+2	1E-7	3E-10	–	–
52	Tellurium-129[b/]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	–	7E+4	3E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
52	Tellurium-131m	D, see ^{116}Te	3E+2 Thyroid (6E+2)	4E+2 Thyroid (1E+3)	2E-7 –	– 2E-9	– 8E-6	– 8E-5
		W, see ^{116}Te	– –	4E+2 Thyroid (9E+2)	2E-7 –	– 1E-9	– –	– –
52	Tellurium-131[b]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 8E-5	– 8E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8 –	– 1E-9	– 9E-6	– 9E-5
		W, see ^{116}Te	– –	2E+2 Thyroid (6E+2)	9E-8 –	– 9E-10	– –	– –
52	Tellurium-133m[b]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 9E-5	– 9E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-133[b]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– 4E-4	– 4E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– –	– –
52	Tellurium-134[b]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– 3E-4	– 3E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– –	– –
53	Iodine-120m[b]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 –	9E-6 –	3E-8 –	– 2E-4	– 2E-3
53	Iodine-120[b]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6 –	– 2E-8	– 1E-4	– 1E-3

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 –	– 7E-8	– 4E-4	– 4E-3
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 –	– 4E-10	– 2E-6	– 2E-5
53	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 –	– 3E-10	– 2E-6	– 2E-5
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-128[b/]	D, all compounds	4E+4 St wall (6E+4)	1E+5 –	5E-5 –	2E-7 –	– 8E-4	– 8E-3
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 –	– 4E-11	– 2E-7	– 2E-6
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 –	– 3E-9	– 2E-5	– 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-132m[b/]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 –	– 3E-8	– 1E-4	– 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 –	– 1E-9	– 7E-6	– 7E-5
53	Iodine-134[b/]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 –	2E-5 –	6E-8 –	– 4E-4	– 4E-3

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 –	– 6E-9	– 3E-5	– 3E-4
54	Xenon-120[b/]	Submersion[a/]	–	–	1E-5	4E-8	–	–
54	Xenon-121[b/]	Submersion[a/]	–	–	2E-6	1E-8	–	–
54	Xenon-122	Submersion[a/]	–	–	7E-5	3E-7	–	–
54	Xenon-123	Submersion[a/]	–	–	6E-6	3E-8	–	–
54	Xenon-125	Submersion[a/]	–	–	2E-5	7E-8	–	–
54	Xenon-127	Submersion[a/]	–	–	1E-5	6E-8	–	–
54	Xenon-129m	Submersion[a/]	–	–	2E-4	9E-7	–	–
54	Xenon-131m	Submersion[a/]	–	–	4E-4	2E-6	–	–
54	Xenon-133m	Submersion[a/]	–	–	1E-4	6E-7	–	–
54	Xenon-133	Submersion[a/]	–	–	1E-4	5E-7	–	–
54	Xenon-135m[b/]	Submersion[a/]	–	–	9E-6	4E-8	–	–
54	Xenon-135	Submersion[a/]	–	–	1E-5	7E-8	–	–
54	Xenon-138[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
55	Cesium-125[b/]	D, all compounds	5E+4 St wall (9E+4)	1E+5 –	6E-5 –	2E-7 –	– 1E-3	– 1E-2
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[b/]	D, all compounds	6E+4 St wall (1E+5)	2E+5 –	8E-5 –	3E-7 –	– 1E-3	– 1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5 St wall (1E+5)	1E+5 –	6E-5 –	2E-7 –	– 2E-3	– 2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
55	Cesium-135m[b/]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[b/]	D, all compounds	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
56	Barium-126[b/]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[b/]	D, all compounds	4E+5	1E+6	6E-4	2E-6	–	–
			St wall (5E+5)	–	–	–	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[b/]	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
56	Barium-141[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[b/]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[b/]	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	–	2E+5	7E-5	2E-7	–	–
57	Lanthanum-132	D, see ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1	3E-8	–	2E-4	2E-3
			–	Liver (7E+1)	–	1E-10	–	–
		W, see ^{131}La	–	3E+2	1E-7	–	–	–
			–	Liver (3E+2)	–	4E-10	–	–
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	–	1E+1	6E-9	2E-11	–	–
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	–	1E+3	5E-7	2E-9	–	–
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-142[b/]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	–	3E+4	1E-5	5E-8	–	–
57	Lanthanum-143[b/]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	–	7E+2	3E-7	9E-10	–	–
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	–	4E+3	1E-6	5E-9	–	–
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	4E+3	2E-6	5E-9	–	–
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	–	1E+5	5E-5	2E-7	–	–
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	–	7E+2	3E-7	9E-10	–	–
58	Cerium-141	W, see ^{134}Ce	2E+3	7E+2	3E-7	1E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	6E+2	2E-7	8E-10	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
58	Cerium-143	W, see ^{134}Ce	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{134}Ce	–	2E+3	7E-7	2E-9	–	–
58	Cerium-144	W, see ^{134}Ce	2E+2	3E+1	1E-8	4E-11	–	–
			LLI wall (3E+2)	–	–	–	3E-6	3E-5
		Y, see ^{134}Ce	–	1E+1	6E-9	2E-11	–	–
59	Praseodymium-136[b/]	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	–	2E+5	9E-5	3E-7	–	–
59	Praseodymium-137[b/]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	–	4E+4	2E-5	6E-8	–	–
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-142m[b/]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	–	2E+3	8E-7	3E-9	–	–
59	Praseodymium-143	W, see ^{136}Pr	9E+2	8E+2	3E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Pr	–	7E+2	3E-7	9E-10	–	–
59	Praseodymium-144[b/]	W, see ^{136}Pr	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	–	8E+3	3E-6	1E-8	–	–
59	Praseodymium-147[b/]	W, see ^{136}Pr	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		Y, see ^{136}Pr	–	2E+5	8E-5	3E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
60	Neodymium-136[b/]	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydroxides, carbides, and fluorides	–	5E+4	2E-5	8E-8	–	–
60	Neodymium-138	W, see ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	–	1E+4	6E-6	2E-8	–	–
60	Neodymium-139[b/]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	–	3E+5	1E-4	4E-7	–	–
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	–	6E+5	3E-4	9E-7	–	–
60	Neodymium-147	W, see ^{136}Nd	1E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Nd	–	8E+2	4E-7	1E-9	–	–
60	Neodymium-149[b/]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	–	2E+4	1E-5	3E-8	–	–
60	Neodymium-151[b/]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	–	2E+5	8E-5	3E-7	–	–
61	Promethium-141[b/]	W, all compounds except those given for Y	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
		Y, oxides, hydroxides, carbides, and fluorides	–	2E+5	7E-5	2E-7	–	–
61	Promethium-143	W, see ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	7E+2	3E-7	1E-9	–	–
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	–	1E+2	5E-8	2E-10	–	–
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2	7E-8	–	1E-4	1E-3
			–	Bone surf (2E+2)	–	3E-10	–	–
		Y, see ^{141}Pm	–	2E+2	8E-8	3E-10	–	–
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	–	4E+1	2E-8	6E-11	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
61	Promethium-147	W, see ^{141}Pm	4E+3	1E+2	5E-8	–	–	–
			LLI wall	Bone surf				
			(5E+3)	(2E+2)	–	3E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	1E+2	6E-8	2E-10	–	–
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	–	3E+2	1E-7	5E-10	–	–
61	Promethium-148	W, see ^{141}Pm	4E+2	5E+2	2E-7	8E-10	–	–
			LLI wall					
			(5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{141}Pm	–	5E+2	2E-7	7E-10	–	–
61	Promethium-149	W, see ^{141}Pm	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall					
			(1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{141}Pm	–	2E+3	8E-7	2E-9	–	–
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	–	2E+4	7E-6	2E-8	–	–
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	–	3E+3	1E-6	4E-9	–	–
62	Samarium-141m[b/]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[b/]	W, all compounds	5E+4	2E+5	8E-5	2E-7	–	–
			St wall					
			(6E+4)	–	–	–	8E-4	8E-3
62	Samarium-142[b/]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1	4E-2	1E-11	–	–	–
			Bone surf	Bone surf				
			(3E+1)	(6E-2)	–	9E-14	3E-7	3E-6
62	Samarium-147	W, all compounds	2E+1	4E-2	2E-11	–	–	–
			Bone surf	Bone surf				
			(3E+1)	(7E-2)	–	1E-13	4E-7	4E-6
62	Samarium-151	W, all compounds	1E+4	1E+2	4E-8	–	–	–
			LLI wall	Bone surf				
			(1E+4)	(2E+2)	–	2E-10	2E-4	2E-3
62	Samarium-153	W, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall					
			(2E+3)	–	–	–	3E-5	3E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
62	Samarium-155[b/]	W, all compounds	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1	4E-8	–	5E-5	5E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[b/]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[b/]	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	–	2E+5	7E-5	2E-7	–	–
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	–	3E+2	1E-7	4E-10	–	–
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	–	4E+3	1E-6	5E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
64	Gadolinium-148	D, see ^{145}Gd	1E+1 Bone surf (2E+1)	8E+3 Bone surf (2E-2)	3E-12 –	– 2E-14	– 3E-7	– 3E-6
		W, see ^{145}Gd	– –	3E-2 Bone surf (6E-2)	1E-11 –	– 8E-14	– –	– –
64	Gadolinium-149	D, see ^{145}Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
		W, see ^{145}Gd	–	2E+3	1E-6	3E-9	–	–
64	Gadolinium-151	D, see ^{145}Gd	6E+3 –	4E+2 Bone surf (6E+2)	2E-7 –	– 9E-10	9E-5 –	9E-4 –
		W, see ^{145}Gd	–	1E+3	5E-7	2E-9	–	–
64	Gadolinium-152	D, see ^{145}Gd	2E+1 Bone surf (3E+1)	1E-2 Bone surf (2E-2)	4E-12 –	– 3E-14	– 4E-7	– 4E-6
		W, see ^{145}Gd	– –	4E-2 Bone surf (8E-2)	2E-11 –	– 1E-13	– –	– –
64	Gadolinium-153	D, see ^{145}Gd	5E+3 –	1E+2 Bone surf (2E+2)	6E-8 –	– 3E-10	6E-5 –	6E-4 –
		W, see ^{145}Gd	–	6E+2	2E-7	8E-10	–	–
64	Gadolinium-159	D, see ^{145}Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{145}Gd	–	6E+3	2E-6	8E-9	–	–
65	Terbium-147[b]	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65	Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	7E-5	7E-4
65	Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65	Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65	Terbium-153	W, all compounds	5E+3	7E+3	3E-6	1E-8	7E-5	7E-4
65	Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65	Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3
65	Terbium-156m (24.4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65	Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
65	Terbium-157	W, all compounds	5E+4	3E+2	1E-7	–	–	–
			LLI wall (5E+4)	Bone surf (6E+2)	–	8E-10	7E-4	7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3	2E+3	7E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2	7E+2	3E-7	1E-9	–	–
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
67	Holmium-155[b/]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157[b/]	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159[b/]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[b/]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[b/]	W, all compounds	5E+5	2E+6	1E-3	3E-6	–	–
			St wall (8E+5)	–	–	–	1E-2	1E-1
67	Holmium-164m[b/]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[b/]	W, all compounds	2E+5	6E+5	3E-4	9E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (9E+2)	–	–	–	1E-5	1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3
68	Erbium-169	W, all compounds	3E+3	3E+3	1E-6	4E-9	–	-
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	–	-
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
69	Thulium-162[b]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (7E+4)	–	–	–	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	–	-
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	–	-
			LLI wall (1E+3)	–	–	–	1E-5	1E-4
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	–	–	-
			LLI wall (1E+4)	Bone surf (6E+2)	–	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	–	-
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[b]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (9E+4)	–	–	–	1E-3	1E-2
70	Ytterbium-162[b]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	–	3E+5	1E-4	4E-7	–	-
70	Ytterbium-166	W, see ^{162}Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	2E+3	8E-7	3E-9	–	-

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
70	Ytterbium-167[b/]	W, see ^{162}Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2
		Y, see ^{162}Yb	–	7E+5	3E-4	1E-6	–	–
70	Ytterbium-169	W, see ^{162}Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	7E+2	3E-7	1E-9	–	–
70	Ytterbium-175	W, see ^{162}Yb	3E+3 LLI wall (3E+3)	4E+3 –	1E-6 –	5E-9 –	– 4E-5	– 4E-4
		Y, see ^{162}Yb	–	3E+3	1E-6	5E-9	–	–
70	Ytterbium-177[b/]	W, see ^{162}Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	5E+4	2E-5	6E-8	–	–
70	Ytterbium-178[b/]	W, see ^{162}Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	4E+4	2E-5	5E-8	–	–
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	–	4E+3	2E-6	6E-9	–	–
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	–	1E+3	5E-7	2E-9	–	–
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2 Bone surf (5E+2)	1E-7 -	– 6E-10	7E-5 –	7E-4 –
		Y, see ^{169}Lu	–	3E+2	1E-7	4E-10	–	–
71	Lutetium-174m	W, see ^{169}Lu	2E+3 LLI wall (3E+3)	2E+2 Bone surf (3E+2)	1E-7 –	– 5E-10	– 4E-5	– 4E-4
		Y, see ^{169}Lu	–	2E+2	9E-8	3E-10	–	–
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2 Bone surf (2E+2)	5E-8 –	– 3E-10	7E-5 –	7E-4 –
		Y, see ^{169}Lu	–	2E+2	6E-8	2E-10	–	–
71	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	–	2E+4	9E-6	3E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0	2E-9	–	1E-5	1E-4
			–	Bone surf (1E+1)	–	2E-11	–	–
		Y, see ^{169}Lu	–	8E+0	3E-9	1E-11	–	–
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2	5E-8	–	1E-5	1E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
		Y, see ^{169}Lu	–	8E+1	3E-8	1E-10	–	–
71	Lutetium-177	W, see ^{169}Lu	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		Y, see ^{169}Lu	–	2E+3	9E-7	3E-9	–	–
71	Lutetium-178m[b/]	W, see ^{169}Lu	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
		Y, see ^{169}Lu	–	2E+5	7E-5	2E-7	–	–
71	Lutetium-178[b/]	W, see ^{169}Lu	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{169}Lu	–	1E+5	5E-5	2E-7	–	–
71	Lutetium-179	W, see ^{169}Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu	–	2E+4	6E-6	3E-8	–	–
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	–	5E+3	2E-6	6E-9	–	–
72	Hafnium-172	D, see ^{170}Hf	1E+3	9E+0	4E-9	–	2E-5	2E-4
			–	Bone surf (2E+1)	–	3E-11	–	–
		W, see ^{170}Hf	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	–	1E+4	5E-6	2E-8	–	–
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2	4E-7	–	4E-5	4E-4
			–	Bone surf (1E+3)	–	1E-9	–	–
		W, see ^{170}Hf	–	1E+3	5E-7	2E-9	–	–
72	Hafnium-177m[b/]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	–	9E+4	4E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0	5E-10	–	3E-6	3E-5
			–	Bone surf (2E+0)	–	3E-12	–	–
		W, see ^{170}Hf	–	5E+0	2E-9	–	–	–
			–	Bone surf (9E+0)	–	1E-11	–	–
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2	1E-7	–	1E-5	1E-4
			–	Bone surf (6E+2)	–	8E-10	–	–
		W, see ^{170}Hf	–	6E+2	3E-7	8E-10	–	–
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	–	3E+4	1E-5	4E-8	–	–
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2	7E-8	–	2E-5	2E-4
			–	Bone surf (4E+2)	–	6E-10	–	–
		W, see ^{170}Hf	–	4E+2	2E-7	6E-10	–	–
72	Hafnium-182m[b/]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	–	1E+5	6E-5	2E-7	–	–
72	Hafnium-182	D, see ^{170}Hf	2E+2	8E-1	3E-10	–	–	–
			Bone surf (4E+2)	Bone surf (2E+0)	–	2E-12	5E-6	5E-5
		W, see ^{170}Hf	–	3E+0	1E-9	–	–	–
			–	Bone surf (7E+0)	–	1E-11	–	–
72	Hafnium-183[b/]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	–	6E+4	2E-5	8E-8	–	–
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	–	6E+3	3E-6	9E-9	–	–
73	Tantalum-172[b/]	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	–	1E+5	4E-5	1E-7	–	–
73	Tantalum-173	W, see ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-174[b/]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	9E+4	4E-5	1E-7	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	–	1E+4	6E-6	2E-8	–	–
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	–	1E+4	5E-6	2E-8	–	–
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	–	7E+4	3E-5	1E-7	–	–
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	–	9E+2	4E-7	1E-9	–	–
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	–	6E+4	2E-5	8E-8	–	–
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	–	2E+1	1E-8	3E-11	–	–
73	Tantalum-182m[b]	W, see ^{172}Ta	2E+5	5E+5	2E-4	8E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
		Y, see ^{172}Ta	–	4E+5	2E-4	6E-7	–	–
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	–	1E+2	6E-8	2E-10	–	–
73	Tantalum-183	W, see ^{172}Ta	9E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{172}Ta	–	1E+3	4E-7	1E-9	–	–
73	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	–	5E+3	2E-6	7E-9	–	–
73	Tantalum-185[b]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	6E+4	3E-5	9E-8	–	–
73	Tantalum-186[b]	W, see ^{172}Ta	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, see ^{172}Ta	–	2E+5	9E-5	3E-7	–	–
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I: Col. 2 Inhalation ALI (µCi)	Table I: Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
74	Tungsten-179[b/]	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3	7E+3	3E-6	9E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
75	Rhenium-177[b/]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	–	4E+5	1E-4	5E-7	–	–
75	Rhenium-178[b/]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		W, see ^{177}Re	–	3E+5	1E-4	4E-7	–	–
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	–	9E+3	4E-6	1E-8	–	–
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	–	2E+4	6E-6	2E-8	–	–
75	Rhenium-182 (64.0 h)	D, see ^{177}Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+3	9E-7	3E-9	–	–
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	4E+2	2E-7	6E-10	–	–
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	–	1E+3	6E-7	2E-9	–	–
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	–	–	–
			St wall (2E+3)	St wall (2E+3)	–	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+2	6E-8	2E-10	–	–
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	2E+3	7E-7	2E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5 St wall (9E+5)	4E-4	–	8E-3	8E-2
			–		–	1E-6	–	–
		W, see ^{177}Re	–	1E+5	4E-5	1E-7	–	–
75	Rhenium-188m[b]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	–	1E+5	6E-5	2E-7	–	–
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	–	3E+3	1E-6	4E-9	–	–
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	–	4E+3	2E-6	6E-9	–	–
76	Osmium-180[b]	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	–	5E+5	2E-4	7E-7	–	–
		Y, oxides and hydroxides	–	5E+5	2E-4	6E-7	–	–
76	Osmium-181[b]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	–	5E+4	2E-5	6E-8	–	–
		Y, see ^{180}Os	–	4E+4	2E-5	6E-8	–	–
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{180}Os	–	2E+5	7E-5	2E-7	–	–
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	–	2E+4	8E-6	3E-8	–	–
		Y, see ^{180}Os	–	2E+4	7E-6	2E-8	–	–
76	Osmium-191	D, see ^{180}Os	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	3E-5	3E-4
		W, see ^{180}Os	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{180}Os	–	1E+3	6E-7	2E-9	–	–
76	Osmium-193	D, see ^{180}Os	2E+3	5E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		W, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
76	Osmium-194	D, see ^{180}Os	4E+2	4E+1	2E-8	6E-11	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		W, see ^{180}Os	–	6E+1	2E-8	8E-11	–	–
		Y, see ^{180}Os	–	8E+0	3E-9	1E-11	–	–
77	Iridium-182[b]	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	–	2E+5	6E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	5E-5	2E-7	–	–
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	–	1E+4	5E-6	2E-8	–	–
		Y, see ^{182}Ir	–	1E+4	4E-6	1E-8	–	–
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{182}Ir	–	6E+3	2E-6	8E-9	–	–
77	Iridium-187	D, see ^{182}Ir	1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
		Y, see ^{182}Ir	–	3E+3	1E-6	5E-9	–	–
77	Iridium-189	D, see ^{182}Ir	5E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	7E-5	7E-4
		W, see ^{182}Ir	–	4E+3	2E-6	5E-9	–	–
		Y, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
77	Iridium-190m[b]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{182}Ir	–	2E+5	8E-5	3E-7	–	–
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	–	1E+3	4E-7	1E-9	–	–
		Y, see ^{182}Ir	–	9E+2	4E-7	1E-9	–	–
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
		Y, see ^{182}Ir	–	2E+1	6E-9	2E-11	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values Col. 2 Inhalation ALI (µCi)	Table I Occupational Values Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations Col. 1 Air (µCi/ml)	Table II Effluent Concentrations Col. 2 Water (µCi/ml)	Table III Releases to Sewers Monthly Average Concentration (µCi/ml)
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	–	4E+2	2E-7	6E-10	–	–
		Y, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{182}Ir	–	1E+2	4E-8	1E-10	–	–
77	Iridium-194	D, see ^{182}Ir	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	–	2E+3	9E-7	3E-9	–	–
		Y, see ^{182}Ir	–	2E+3	8E-7	3E-9	–	–
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	2E+4	9E-6	3E-8	–	–
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	–	5E+4	2E-5	7E-8	–	–
		Y, see ^{182}Ir	–	4E+4	2E-5	6E-8	–	–
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	–	–
			LLI wall (3E+4)	–	–	–	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	–	–
			LLI wall (5E+4)	–	–	–	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
78	Platinum-197m[b]	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78	Platinum-199[b]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78	Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
79	Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, halides and nitrates	–	2E+4	9E-6	3E-8	–	–
		Y, oxides and hydroxides	–	2E+4	8E-6	3E-8	–	–
79	Gold-194	D, see ^{193}Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193}Au	–	5E+3	2E-6	8E-9	–	–
		Y, see ^{193}Au	–	5E+3	2E-6	7E-9	–	–
79	Gold-195	D, see ^{193}Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{193}Au	–	1E+3	6E-7	2E-9	–	–
		Y, see ^{193}Au	–	4E+2	2E-7	6E-10	–	–
79	Gold-198m	D, see ^{193}Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{193}Au	–	1E+3	5E-7	2E-9	–	–
		Y, see ^{193}Au	–	1E+3	5E-7	2E-9	–	–
79	Gold-198	D, see ^{193}Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	–	2E+3	8E-7	3E-9	–	–
		Y, see ^{193}Au	–	2E+3	7E-7	2E-9	–	–
79	Gold-199	D, see ^{193}Au	3E+3	9E+3	4E-6	1E-8	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		W, see ^{193}Au	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{193}Au	–	4E+3	2E-6	5E-9	–	–
79	Gold-200m	D, see ^{193}Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{193}Au	–	2E+4	1E-6	3E-9	–	–
79	Gold-200[b]	D, see ^{193}Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{193}Au	–	8E+4	3E-5	1E-7	–	–
		Y, see ^{193}Au	–	7E+4	3E-5	1E-7	–	–
79	Gold-201[b]	D, see ^{193}Au	7E+4	2E+5	9E-5	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{193}Au	–	2E+5	1E-4	3E-7	–	–
		Y, see ^{193}Au	–	2E+5	9E-5	3E-7	–	–
80	Mercury-193m	Vapor	–	8E+3	4E-6	1E-8	–	–
		Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, oxides, hydroxides, halides, nitrates, and sulfides	–	8E+3	3E-6	1E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
80	Mercury-193	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	4E+4	2E-5	6E-8	–	–
80	Mercury-194	Vapor	–	3E+1	1E-8	4E-11	–	–
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	–	1E+2	5E-8	2E-10	–	–
80	Mercury-195m	Vapor	–	4E+3	2E-6	6E-9	–	–
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	4E+3	2E-6	5E-9	–	–
80	Mercury-195	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	3E+4	1E-5	5E-8	–	–
80	Mercury-197m	Vapor	–	5E+3	2E-6	7E-9	–	–
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	–	5E+3	2E-6	7E-9	–	–
80	Mercury-197	Vapor	–	8E+3	4E-6	1E-8	–	–
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	–	9E+3	4E-6	1E-8	–	–
80	Mercury-199m[b]	Vapor	–	8E+4	3E-5	1E-7	–	–
		Organic D	6E+4	2E+5	7E-5	2E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	–	2E+5	7E-5	2E-7	–	–
80	Mercury-203	Vapor	–	8E+2	4E-7	1E-9	–	–
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	1E+3	5E-7	2E-9	–	–
81	Thallium-194m[b]	D, all compounds	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
81	Thallium-194[b]	D, all compounds	3E+5	6E+5	2E-4	8E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
81	Thallium-195[b]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[b/]	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m[b/]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf (1E+0)	2E-1 Bone surf (4E-1)	1E-10 –	– 6E-13	– 1E-8	– 1E-7
82	Lead-211[b/]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf (1E+2)	3E+1 –	1E-8 –	5E-11 –	– 2E-6	– 2E-5
82	Lead-214[b/]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[b/]	D, nitrates W, all other compounds	3E+4 –	8E+4 1E+5	4E-5 4E-5	1E-7 1E-7	4E-4 –	4E-3 –

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (µCi)	Col. 2 Inhalation ALI (µCi)	Col. 3 Inhalation DAC (µCi/ml)	Col. 1 Air (µCi/ml)	Col. 2 Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
83	Bismuth-201[b/]	D, see ^{200}Bi	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{200}Bi	–	4E+4	2E-5	5E-8	–	–
83	Bismuth-202[b/]	D, see ^{200}Bi	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{200}Bi	–	8E+4	3E-5	1E-7	–	–
83	Bismuth-203	D, see ^{200}Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{200}Bi	–	6E+3	3E-6	9E-9	–	–
83	Bismuth-205	D, see ^{200}Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{200}Bi	–	1E+3	5E-7	2E-9	–	–
83	Bismuth-206	D, see ^{200}Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{200}Bi	–	9E+2	4E-7	1E-9	–	–
83	Bismuth-207	D, see ^{200}Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-210m	D, see ^{200}Bi	4E+1 Kidneys (6E+1)	5E+0 Kidneys (6E+0)	2E-9 –	– 9E-12	– 8E-7	– 8E-6
		W, see ^{200}Bi	–	7E-1	3E-10	9E-13	–	–
83	Bismuth-210	D, see ^{200}Bi	8E+2	2E+2	1E-7	–	1E-5	1E-4
			–	Kidneys (4E+2)	–	5E-10	–	–
		W, see ^{200}Bi	–	3E+1	1E-8	4E-11	–	–
83	Bismuth-212[b/]	D, see ^{200}Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W, see ^{200}Bi	–	3E+2	1E-7	4E-10	–	–
83	Bismuth-213[b/]	D, see ^{200}Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-214[b/]	D, see ^{200}Bi	2E+4 St wall (2E+4)	8E+2 –	3E-7 –	1E-9 –	– 3E-4	– 3E-3
		W, see ^{200}Bi	–	9E-2	4E-7	1E-9	–	–
84	Polonium-203[b/]	D, all compounds except those given for W	3E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, oxides, hydroxides, and nitrates	–	9E+4	4E-5	1E-7	–	–
84	Polonium-205[b/]	D, see ^{203}Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
		W, see ^{203}Po	–	7E+4	3E-5	1E-7	–	–
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	–	3E+4	1E-5	4E-8	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	–	6E-1	3E-10	9E-13	–	–
85	Astatine-207[b]	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
		W	–	2E+3	9E-7	3E-9	–	–
85	Astatine-211	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
		W	–	5E+1	2E-8	8E-11	–	–
86	Radon-220	With daughters removed	–	2E+4	7E-6	2E-8	–	–
		With daughters present	–	2E+1 (or 12 WLM)	9E-9 (or 1.0 WL)	3E-11	–	–
86	Radon-222	With daughters removed	–	1E+4	4E-6	1E-8	–	–
		With daughters present	–	1E+2 (or 4 WLM)	3E-8 (or 0.33 WL)	1E-10	–	–
87	Francium-222[b]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[b]	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88	Radium-223	W, all compounds	5E+0 Bone surf (9E+0)	7E-1	3E-10	9E-13	–	–
				–	–	–	1E-7	1E-6
88	Radium-224	W, all compounds	8E+0 Bone surf (2E+1)	2E+0	7E-10	2E-12	–	–
				–	–	–	2E-7	2E-6
88	Radium-225	W, all compounds	8E+0 Bone surf (2E+1)	7E-1	3E-10	9E-13	–	–
				–	–	–	2E-7	2E-6
88	Radium-226	W, all compounds	2E+0 Bone surf (5E+0)	6E-1	3E-10	9E-13	–	–
				–	–	–	6E-8	6E-7
88	Radium-227[b]	W, all compounds	2E+4 Bone surf (2E+4)	1E+4 Bone surf (2E+4)	6E-6	–	–	–
					–	3E-8	3E-4	3E-3
88	Radium-228	W, all compounds	2E+0 Bone surf (4E+0)	1E+0	5E-10	2E-12	–	–
				–	–	–	6E-8	6E-7

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
89	Actinium-224	D, all compounds except those given for W and Y	2E+3	3E+1	1E-8	–	–	–
			LLI wall (2E+3)	Bone surf (4E+1)	–	5E-11	3E-5	3E-4
		W, halides and nitrates	–	5E+1	2E-8	7E-11	–	–
		Y, oxides and hydroxides	–	5E+1	2E-8	6E-11	–	–
89	Actinium-225	D, see ^{224}Ac	5E+1	3E-1	1E-10	–	–	–
			LLI wall (5E+1)	Bone surf (5E-1)	-	7E-13	7E-7	7E-6
		W, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
		Y, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
89	Actinium-226	D, see ^{224}Ac	1E+2	3E+0	1E-9	–	–	–
			LLI wall (1E+2)	Bone surf (4E+0)	–	5E-12	2E-6	2E-5
		W, see ^{224}Ac	–	5E+0	2E-9	7E-12	–	–
		Y, see ^{224}Ac	–	5E+0	2E-9	6E-12	–	–
89	Actinium-227	D, see ^{224}Ac	2E-1	4E-4	2E-13	–	–	–
			Bone surf (4E-1)	Bone surf (8E-4)	–	1E-15	5E-9	5E-8
		W, see ^{224}Ac	–	2E-3	7E-13	–	–	–
			–	Bone surf (3E-3)	–	4E-15	–	–
		Y, see ^{224}Ac	–	4E-3	2E-12	6E-15	–	–
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	–	3E-5	3E-4
			–	Bone surf (2E+1)	–	2E-11	–	–
		W, see ^{224}Ac	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{224}Ac	–	4E+1	2E-8	6E-11	–	–
90	Thorium-226[b]	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	–	–
			St wall (5E+3)	–	–	–	7E-5	7E-4
		Y, oxides and hydroxides	–	1E+2	6E-8	2E-10	–	–
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	–	3E-1	1E-10	5E-13	–	–
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	–	–	–
			Bone surf (1E+1)	Bone surf (2E-2)	–	3E-14	2E-7	2E-6
		Y, see ^{226}Th	–	2E-2	7E-12	2E-14	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
90	Thorium-229	W, see ^{226}Th	6E-1 Bone surf (1E+0)	9E-4 Bone surf (2E-3)	4E-13 –	– 3E-15	– 2E-8	– 2E-7
		Y, see ^{226}Th	– –	2E-3 Bone surf (3E-3)	1E-12 –	– 4E-15	– –	– –
90	Thorium-230	W, see ^{226}Th	4E+0 Bone surf (9E+0)	6E-3 Bone surf (2E-2)	3E-12 –	– 2E-14	– 1E-7	– 1E-6
		Y, see ^{226}Th	– –	2E-2 Bone surf (2E-2)	6E-12 –	– 3E-14	– –	– –
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	–	6E+3	3E-6	9E-9	–	–
90	Thorium-232	W, see ^{226}Th	7E-1 Bone surf (2E+0)	1E-3 Bone surf (3E-3)	5E-13 –	– 4E-15	– 3E-8	– 3E-7
		Y, see ^{226}Th	– –	3E-3 Bone sur (4E-3)	1E-12 –	– 6E-15	– –	– –
90	Thorium-234	W, see ^{226}Th	3E+2 LLI wall (4E+2)	2E+2 –	8E-8 –	3E-10 –	– 5E-6	– 5E-5
		Y, see ^{226}Th	–	2E+2	6E-8	2E-10	–	–
91	Protactinium-227[b]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	–	1E+2	4E-8	1E-10	–	–
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1 Bone surf (2E+1)	5E-9 –	– 3E-11	2E-5 –	2E-4 –
		Y, see ^{227}Pa	–	1E+1	5E-9	2E-11	–	–
91	Protactinium-230	W, see ^{227}Pa	6E+2 Bone surf (9E+2)	5E+0 –	2E-9 –	7E-12 –	– 1E-5	– 1E-4
		Y, see ^{227}Pa	–	4E+0	1E-9	5E-12	–	–
91	Protactinium-231	W, see ^{227}Pa	2E-1 Bone surf (5E-1)	2E-3 Bone surf (4E-3)	6E-13 –	– 6E-15	– 6E-9	– 6E-8
		Y, see ^{227}Pa	– –	4E-3 Bone surf (6E-3)	2E-12 –	– 8E-15	– –	– –

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1	9E-9	–	2E-5	2E-4
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{227}Pa	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	1E-10	–	–
91	Protactinium-233	W, see ^{227}Pa	1E+3	7E+2	3E-7	1E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		Y, see ^{227}Pa	–	6E+2	2E-7	8E-10	–	–
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	–	7E+3	3E-6	9E-9	–	–
92	Uranium-230	D, UF_6, UO_2F_2, $UO_2(NO_3)_2$	4E+0	4E-1	2E-10	–	–	–
			Bone surf (6E+0)	Bone surf (6E-1)	–	8E-13	8E-8	8E-7
		W, UO_3, UF_4, UCl_4	–	4E-1	1E-10	5E-13	–	–
		Y, UO_2, U_3O_8	–	3E-1	1E-10	4E-13	–	–
92	Uranium-231	D, see ^{230}U	5E+3	8E+3	3E-6	1E-8	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{230}U	–	6E+3	2E-6	8E-9	–	–
		Y, see ^{230}U	–	5E+3	2E-6	6E-9	–	–
92	Uranium-232	D, see ^{230}U	2E+0	2E-1	9E-11	–	–	–
			Bone surf (4E+0)	Bone surf (4E-1)	–	6E-13	6E-8	6E-7
		W, see ^{230}U	–	4E-1	2E-10	5E-13	–	–
		Y, see ^{230}U	–	8E-3	3E-12	1E-14	–	–
92	Uranium-233	D, see ^{230}U	1E+1	1E+0	5E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–
92	Uranium-234[e]	D, see ^{230}U	1E+1	1E+0	5E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-235[c]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-236	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-237	D, see ^{230}U	2E+3 LLI wall (2E+3)	3E+3 –	1E-6 –	4E-9 -	– 3E-5	– 3E-4
		W, see ^{230}U	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{230}U	–	2E+3	6E-7	2E-9	–	–
92	Uranium-238[c]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-239[b]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	–	2E+5	7E-5	2E-7	–	–
		Y, see ^{230}U	–	2E+5	6E-5	2E-7	–	–
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{230}U	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{230}U	–	2E+3	1E-6	3E-9	–	–
92	Uranium-natural[c]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	– 3E-12	– 3E-7	– 3E-6
		W, see ^{230}U	–	8E-1	3E-10	9E-13	–	–
		Y, see ^{230}U	–	5E-2	2E-11	9E-14	–	–
93	Neptunium-232[b]	W, all compounds	1E+5 –	2E+3 Bone surf (5E+2)	7E-7 –	– 6E-9	2E-3 –	2E-2 –
93	Neptunium-233[b]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4 LLI wall (2E+4)	8E+2 Bone surf (1E+3)	3E-7 –	– 2E-9	– 3E-4	– 3E-3

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
93	Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0 Bone surf (6E+0)	2E-2 Bone surf (5E-2)	9E-12 –	– 8E-14	– 9E-8	– 9E-7
93	Neptunium-236 (22.5 h)	W, all compounds	3E+3 Bone surf (4E+3)	3E+1 Bone surf (7E+1)	1E-8 –	– 1E-10	– 5E-5	– 5E-4
93	Neptunium-237	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (1E-2)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
93	Neptunium-238	W, all compounds	1E+3 –	6E+1 Bone surf (2E+2)	3E-8 –	– 2E-10	2E-5 –	2E-4 –
93	Neptunium-239	W, all compounds	2E+3 LLI wall (2E+3)	2E+3 –	9E-7 –	3E-9 –	– 2E-5	– 2E-4
93	Neptunium-240[b]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2 Y, PuO_2	8E+3 –	2E+2 2E+2	9E-8 8E-8	3E-10 3E-10	1E-4 –	1E-3 –
94	Plutonium-235[b]	W, see ^{234}Pu Y, see ^{234}Pu	9E+5 –	3E+6 3E+6	1E-3 1E-3	4E-6 3E-6	1E-2 –	1E-1 –
94	Plutonium-236	W, see ^{234}Pu	2E+0 Bone surf (4E+0)	2E-2 Bone surf (4E-2)	8E-12 –	– 5E-14	– 6E-8	– 6E-7
		Y, see ^{234}Pu	–	4E-2	2E-11	6E-14	–	–
94	Plutonium-237	W, see ^{234}Pu Y, see ^{234}Pu	1E+4 –	3E+3 3E+3	1E-6 1E-6	5E-9 4E-9	2E-4 –	2E-3 –
94	Plutonium-238	W, see ^{234}Pu	9E-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
		Y, see ^{234}Pu	–	2E-2	8E-12	2E-14	–	–
94	Plutonium-239	W, see ^{234}Pu	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
		Y, see ^{234}Pu	– –	2E-2 Bone surf (2E-2)	7E-12 –	– 2E-14	– –	– –

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
94	Plutonium-240	W, see ^{234}Pu	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
		Y, see ^{234}Pu	– –	2E-2 Bone surf (2E-2)	7E-12 –	– 2E-14	– –	– –
94	Plutonium-241	W, see ^{234}Pu	4E+1 Bone surf (7E+1)	3E-1 Bone surf (6E-1)	1E-10 –	– 8E-13	– 1E-6	– 1E-5
		Y, see ^{234}Pu	– –	8E-1 Bone surf (1E+0)	3E-10 –	– 1E-12	– –	– –
94	Plutonium-242	W, see ^{234}Pu	8E-1 Bone surf (1E+0)	7E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
		Y, see ^{234}Pu	– –	2E-2 Bone surf (2E-2)	7E-12 –	– 2E-14	– –	– –
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	–	4E+4	2E-5	5E-8	–	–
94	Plutonium-244	W, see ^{234}Pu	8E-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
		Y, see ^{234}Pu	– –	2E-2 Bone surf (2E-2)	7E-12 –	– 2E-14	– –	– –
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	–	4E+3	2E-6	6E-9	–	–
94	Plutonium-246	W, see ^{234}Pu	4E+2 LLI wall (4E+2)	3E+2 –	1E-7 –	4E-10 –	– 6E-6	– 6E-5
		Y, see ^{234}Pu	–	3E+2	1E-7	4E-10	–	–
95	Americium-237[b/]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[b/]	W, all compounds	4E+4 –	3E+3 Bone surf (6E+3)	1E-6 –	– 9E-9	5E-4 –	5E-3 –
95	Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95	Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (µCi)	Col. 2 Inhalation ALI (µCi)	Col. 3 Inhalation DAC (µCi/ml)	Col. 1 Air (µCi/ml)	Col. 2 Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242	W, all compounds	4E+3 –	8E+1 Bone surf (9E+1)	4E-8 –	– 1E-10	5E-5 –	5E-4 –
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-244m[b/]	W, all compounds	6E+4 St wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 –	– 1E-8	– 1E-3	– 1E-2
95	Americium-244	W, all compounds	3E+3 –	2E+2 Bone surf (3E+2)	8E-8 –	– 4E-10	4E-5 –	4E-4 –
95	Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3
95	Americium-246m[b/]	W, all compounds	5E+4 St wall (6E+4)	2E+5 –	8E-5 –	3E-7 –	– 8E-4	– 8E-3
95	Americium-246[b/]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96	Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96	Curium-240	W, all compounds	6E+1 Bone surf (8E+1)	6E-1 Bone surf (6E-1)	2E-10 –	– 9E-13	– 1E-6	– 1E-5
96	Curium-241	W, all compounds	1E+3 –	3E+1 Bone surf (4E+1)	1E-8 –	– 5E-11	2E-5 –	2E-4 –
96	Curium-242	W, all compounds	3E+1 Bone surf (5E+1)	3E-1 Bone surf (3E-1)	1E-10 –	– 4E-13	– 7E-7	– 7E-6
96	Curium-243	W, all compounds	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 –	– 2E-14	– 3E-8	– 3E-7

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I: Col. 2 Inhalation ALI (µCi)	Table I: Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
96	Curium-244	W, all compounds	1E+0	1E-2	5E-12	–	–	–
			Bone surf (3E+0)	Bone surf (2E-2)	–	3E-14	3E-8	3E-7
96	Curium-245	W, all compounds	7E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
96	Curium-246	W, all compounds	7E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
96	Curium-247	W, all compounds	8E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
96	Curium-248	W, all compounds	2E-1	2E-3	7E-13	–	–	–
			Bone surf (4E-1)	Bone surf (3E-3)	–	4E-15	5E-9	5E-8
96	Curium-249[b/]	W, all compounds	5E+4	2E+4	7E-6	–	7E-4	7E-3
			–	Bone surf (3E+4)	–	4E-8	–	–
96	Curium-250	W, all compounds	4E-2	3E-4	1E-13	–	–	–
			Bone surf (6E-2)	Bone surf (5E-4)	–	8E-16	9E-10	9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1	4E-3	2E-12	–	–	–
			Bone surf (1E+0)	Bone surf (9E-3)	–	1E-14	2E-8	2E-7
97	Berkelium-249	W, all compounds	2E+2	2E+0	7E-10	–	–	–
			Bone surf (5E+2)	Bone surf (4E+0)	–	5E-12	6E-6	6E-5
97	Berkelium-250	W, all compounds	9E+3	3E+2	1E-7	–	1E-4	1E-3
			–	Bone surf (7E+2)	–	1E-9	–	–
98	Californium-244[b/]	W, all compounds except those given for Y	3E+4	6E+2	2E-7	8E-10	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		Y, oxides and hydroxides	–	6E+2	2E-7	8E-10	–	–

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	–	9E+0	4E-9	1E-11	–	–
98	Californium-248	W, see ^{244}Cf	8E+0 Bone surf (2E+1)	6E-2 Bone surf (1E-1)	3E-11 –	– 2E-13	– 2E-7	– 2E-6
		Y, see ^{244}Cf	–	1E-1	4E-11	1E-13	–	–
98	Californium-249	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
		Y, see ^{244}Cf	– –	1E-2 Bone surf (1E-2)	4E-12 –	– 2E-14	– –	– –
98	Californium-250	W, see ^{244}Cf	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 –	– 3E-14	– 3E-8	– 3E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	4E-14	–	–
98	Californium-251	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
		Y, see ^{244}Cf	– –	1E-2 Bone surf (1E-2)	4E-12 –	– 2E-14	– –	– –
98	Californium-252	W, see ^{244}Cf	2E+0 Bone surf (5E+0)	2E-2 Bone surf (4E-2)	8E-12 –	– 5E-14	– 7E-8	– 7E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	5E-14	–	–
98	Californium-253	W, see ^{244}Cf	2E+2 Bone surf (4E+2)	2E+0 –	8E-10 –	3E-12 –	– 5E-6	– 5E-5
		Y, see ^{244}Cf	–	2E+0	7E-10	2E-12	–	–
98	Californium-254	W, see ^{244}Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	–	2E-2	7E-12	2E-14	–	–
99	Einsteinium-250	W, all compounds	4E+4	5E+2 Bone surf (1E+3)	2E-7 –	– 2E-9	6E-4 –	6E-3 –
99	Einsteinium-251	W, all compounds	7E+3 –	9E+2 Bone surf (1E+3)	4E-7 –	– 2E-9	1E-4 –	1E-3 –
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5

Footnotes appear at the end of these three tables.

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
99	Einsteinium-254m	W, all compounds	3E+2	1E+1	4E-9	1E-11	–	–
			LLI wall (3E+2)	–	–	–	4E-6	4E-5
99	Einsteinium-254	W, all compounds	8E+0	7E-2	3E-11	–	–	–
			Bone surf (2E+1)	Bone surf (1E-1)	–	2E-13	2E-7	2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1	2E-1	7E-11	–	–	–
			Bone surf (4E+1)	Bone surf (2E-1)	–	3E-13	5E-7	5E-6
101	Mendelevium-257	W, all compounds	7E+3	8E+1	4E-8	–	1E-4	1E-3
			–	Bone surf (9E+1)	–	1E-10	–	–
101	Mendelevium-258	W, all compounds	3E+1	2E-1	1E-10	–	–	–
			Bone surf (5E+1)	Bone surf (3E-1)	–	5E-13	6E-7	6E-6
- 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		Submersion[v]	–	2E+2	1E-7	1E-9	–	–
- 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		....	–	2E-1	1E-10	1E-12	1E-8	1E-7
- Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known		....	–	4E-4	2E-13	1E-15	2E-9	2E-8

Footnotes appear at the end of these three tables.

Footnotes:

[v] *"Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.*

[w] *These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (See D.203.)*

[y] *For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see D.201e.). If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:*

$SA = 3.6E\text{-}7$ *curies/gram U U-depleted*

$SA = [0.4 + 0.38\ (enrichment) + 0.0034\ (enrichment)^2]\ E\text{-}6,\ enrichment \geq 0.72$

where enrichment is the percentage by weight of U-235, expressed as percent.

Note:

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

2. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture; or

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure Effluent Concentrations Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
If it is known that Ac-227-D and Cm-250-W are not present			–	7E-4	3E-13	–	–	–
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present			–	7E-3	3E-12	–	–	–
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not presen			–	7E-2	3E-11	–	–	–

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion ALI (µCi)	Col. 2 Inhalation ALI (µCi)	Col. 3 Inhalation DAC (µCi/ml)	Col. 1 Air (µCi/ml)	Col. 2 Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present			–	7E-1	3E-10	–	–	–
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present			–	7E+0	3E-9	–	–	–
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present			–	–	–	1E-14	–	–
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present			–	–	–	1E-13	–	–
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present			–	–	–	1E-12	–	–
If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present			–	–	–	–	1E-6	1E-5

3. If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

4. If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (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 DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC} SUBB + \frac{C_C}{DAC_C} \leq 1$$

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Hydrogen-3	1,000	Scandium-47	100
Beryllium-7	1,000	Scandium-48	100
Beryllium-10	1	Scandium-49	1,000
Carbon-11	1,000	Titanium-44	1
Carbon-14	100	Titanium-45	1,000
Fluorine-18	1,000	Vanadium-47	1,000
Sodium-22	10	Vanadium-48	100
Sodium-24	100	Vanadium-49	1,000
Magnesium-28	100	Chromium-48	1,000
Aluminum-26	10	Chromium-49	1,000
Silicon-31	1,000	Chromium-51	1,000
Silicon-32	1	Manganese-51	1,000
Phosphorus-32	10	Manganese-52m	1,000
Phosphorus-33	100	Manganese-52	100
Sulfur-35	100	Manganese-53	1,000
Chlorine-36	10	Manganese-54	100
Chlorine-38	1,000	Manganese-56	1,000
Chlorine-39	1,000	Iron-52	100
Argon-39	1,000	Iron-55	100
Argon-41	1,000	Iron-59	10
Potassium-40	100	Iron-60	1
Potassium-42	1,000	Cobalt-55	100
Potassium-43	1,000	Cobalt-56	10
Potassium-44	1,000	Cobalt-57	100
Potassium-45	1,000	Cobalt-58m	1,000
Calcium-41	100	Cobalt-58	100
Calcium-45	100	Cobalt-60m	1,000
Calcium-47	100	Cobalt-60	1
Scandium-43	1,000	Cobalt-61	1,000
Scandium-44m	100	Cobalt-62m	1,000
Scandium-44	100	Nickel-56	100
Scandium-46	10	Nickel-57	100
Nickel-59	100	Copper-61	1,000
Nickel-63	100	Copper-64	1,000
Nickel-65	1,000	Copper-67	1,000
Nickel-66	10	Zinc-62	100
Copper-60	1,000	Zinc-63	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Zinc-65	10	Selenium-73m	1,000
Zinc-69m	100	Selenium-73	100
Zinc-69	1,000	Selenium-75	100
Zinc-71m	1,000	Selenium-79	100
Zinc-72	100	Selenium-81m	1,000
Gallium-65	1,000	Selenium-81	1,000
Gallium-66	100	Selenium-83	1,000
Gallium-67	1,000	Bromine-74m	1,000
Gallium-68	1,000	Bromine-74	1,000
Gallium-70	1,000	Bromine-75	1,000
Gallium-72	100	Bromine-76	100
Gallium-73	1,000	Bromine-77	1,000
Germanium-66	1,000	Bromine-80m	1,000
Germanium-67	1,000	Bromine-80	1,000
Germanium-68	10	Bromine-82	100
Germanium-69	1,000	Bromine-83	1,000
Germanium-71	1,000	Bromine-84	1,000
Germanium-75	1,000	Krypton-74	1,000
Germanium-77	1,000	Krypton-76	1,000
Germanium-78	1,000	Krypton-77	1,000
Arsenic-69	1,000	Krypton-79	1,000
Arsenic-70	1,000	Krypton-81	1,000
Arsenic-71	100	Krypton-83m	1,000
Arsenic-72	100	Krypton-85m	1,000
Arsenic-73	100	Krypton-85	1,000
Arsenic-74	100	Krypton-87	1,000
Arsenic-76	100	Krypton-88	1,000
Arsenic-77	100	Rubidium-79	1,000
Arsenic-78	1,000	Rubidium-81m	1,000
Selenium-70	1,000	Rubidium-81	1,000
Rubidium-82m	1,000	Strontium-83	100
Rubidium-83	100	Strontium-85m	1,000
Rubidium-84	100	Strontium-85	100
Rubidium-86	100	Strontium-87m	1,000
Rubidium-87	100	Strontium-89	10
Rubidium-88	1,000	Strontium-90	0.1
Rubidium-89	1,000	Strontium-91	100
Strontium-80	100	Strontium-92	100
Strontium-81	1,000	Yttrium-86m	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Yttrium-86	100	Niobium-97	1,000
Yttrium-87	100	Niobium-98	1,000
Yttrium-88	10	Molybdenum-90	100
Yttrium-90m	1,000	Molybdenum-93m	100
Yttrium-90	10	Molybdenum-93	10
Yttrium-91m	1,000	Molybdenum-99	100
Yttrium-91	10	Molybdenum-101	1,000
Yttrium-92	100	Technetium-93m	1,000
Yttrium-93	100	Technetium-93	1,000
Yttrium-94	1,000	Technetium-94m	1,000
Yttrium-95	1,000	Technetium-94	1,000
Zirconium-86	100	Technetium-96m	1,000
Zirconium-88	10	Technetium-96	100
Zirconium-89	100	Technetium-97m	100
Zirconium-93	1	Technetium-97	1,000
Zirconium-95	10	Technetium-98	10
Zirconium-97	100	Technetium-99m	1,000
Niobium-88	1,000	Technetium-99	100
Niobium-89m (66 min)	1,000	Technetium-101	1,000
Niobium-89 (122 min)	1,000	Technetium-104	1,000
Niobium-90	100	Ruthenium-94	1,000
Niobium-93m	10	Ruthenium-97	1,000
Niobium-94	1	Ruthenium-103	100
Niobium-95m	100	Ruthenium-105	1,000
Niobium-95	100	Ruthenium-106	1
Niobium-96	100	Rhodium-99m	1,000
Rhodium-99	100	Palladium-107	10
Rhodium-100	100	Palladium-109	100
Rhodium-101m	1,000	Silver-102	1,000
Rhodium-101	10	Silver-103	1,000
Rhodium-102m	10	Silver-104m	1,000
Rhodium-102	10	Silver-104	1,000
Rhodium-103m	1,000	Silver-105	100
Rhodium-105	100	Silver-106m	100
Rhodium-106m	1,000	Silver-106	1,000
Rhodium-107	1,000	Silver-108m	1
Palladium-100	100	Silver-11Om	10
Palladium-101	1,000	Silver-111	100
Palladium-103	100	Silver-112	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Silver-115	1,000	Antimony-117	1,000
Cadmium-104	1,000	Antimony-118m	1,000
Cadmium-107	1,000	Antimony-119	1,000
Cadmium-109	1	Antimony-120 (16 min)	1,000
Cadmium-113m	0.1	Antimony-120 (5.76 d)	100
Cadmium-113	100	Antimony-122	100
Cadmium-115m	10	Antimony-124m	1,000
Cadmium-115	100	Antimony-124	10
Cadmium-117m	1,000	Antimony-125	100
Cadmium-117	1,000	Antimony-126m	1,000
Indium-109	1,000	Antimony-126	100
Indium-110 (69.1 min)	1,000	Antimony-127	100
Indium-11O (4.9 h)	1,000	Antimony-128 (10.4 min)	1,000
Indium-111	100	Antimony-128 (9.O1 h)	100
Indium-112	1,000	Antimony-129	100
Indium-113m	1,000	Antimony-130	1,000
Indium-114m	10	Antimony-131	1,000
Indium-115m	1,000	Tellurium-116	1,000
Indium-115	100	Tellurium-121m	10
Indium-116m	1,000	Tellurium-121	100
Indium-117m	1,000	Tellurium-123m	10
Indium-117	1,000	Tellurium-123	100
Indium-119m	1,000	Tellurium-125m	10
Tin-110	100	Tellurium-127m	10
Tin-111	1,000	Tellurium-127	1,000
Tin-113	100	Tellurium-129m	10
Tin-117m	100	Tellurium-129	1,000
Tin-119m	100	Tellurium-131m	10
Tin-121m	100	Tellurium-131	100
Tin-121	1,000	Tellurium-132	10
Tin-123m	1,000	Tellurium-133m	100
Tin-123	10	Tellurium-133	1,000
Tin-125	10	Tellurium-134	1,000
Tin-126	10	Iodine-120m	1,000
Tin-127	1,000	Iodine-120	100
Tin-128	1,000	Iodine-121	1,000
Antimony-115	1,000	Iodine-123	100
Antimony-116m	1,000	Iodine-124	10
Antimony-116	1,000	Iodine-125	1

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Iodine-126	1	Xenon-133m	1,000
Iodine-128	1,000	Xenon-133	1,000
Iodine-129	1	Xenon-135m	1,000
Iodine-130	10	Xenon-135	1,000
Iodine-131	1	Xenon-138	1,000
Iodine-132m	100	Cesium-125	1,000
Iodine-132	100	Cesium-127	1,000
Iodine-133	10	Cesium-129	1,000
Iodine-134	1,000	Cesium-130	1,000
Iodine-135	100	Cesium-131	1,000
Xenon-120	1,000	Cesium-132	100
Xenon-121	1,000	Cesium-134m	1,000
Xenon-122	1,000	Cesium-134	10
Xenon-123	1,000	Cesium-135m	1,000
Xenon-125	1,000	Cesium-135	100
Xenon-127	1,000	Cesium-136	10
Xenon-129m	1,000	Cesium-137	10
Xenon-131m	1,000	Cesium-138	1,000
Barium-126	1,000	Cerium-135	100
Barium-128	100	Cerium-137m	100
Barium-131m	1,000	Cerium-137	1,000
Barium-131	100	Cerium-139	100
Barium-133m	100	Cerium-141	100
Barium-133	100	Cerium-143	100
Barium-135m	100	Cerium-144	1
Barium-139	1,000	Praseodymium-136	1,000
Barium-140	100	Praseodymium-137	1,000
Barium-141	1,000	Praseodymium-138m	1,000
Barium-142	1,000	Praseodymium-139	1,000
Lanthanum-131	1,000	Praseodymium-142m	1,000
Lanthanum-132	100	Praseodymium-142	100
Lanthanum-135	1,000	Praseodymium-143	100
Lanthanum-137	10	Praseodymium-144	1,000
Lanthanum-138	100	Praseodymium-145	100
Lanthanum-140	100	Praseodymium-147	1,000
Lanthanum-141	100	Neodymium-136	1,000
Lanthanum-142	1,000	Neodymium-138	100
Lanthanum-143	1,000	Neodymium-139m	1,000
Cerium-134	100	Neodymium-139	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Neodymium-141	1,000	Promethium-151	100
Neodymium-147	100	Samarium-141m	1,000
Neodymium-149	1,000	Samarium-141	1,000
Neodymium-151	1,000	Samarium-142	1,000
Promethium-141	1,000	Samarium-145	100
Promethium-143	100	Samarium-146	1
Promethium-144	10	Samarium-147	100
Promethium-145	10	Samarium-151	10
Promethium-146	1	Samarium-153	100
Promethium-147	10	Samarium-155	1,000
Promethium-148m	10	Samarium-156	1,000
Promethium-148	10	Europium-145	100
Promethium-149	100	Europium-146	100
Promethium-150	1,000	Europium-147	100
Europium-148	10	Terbium-154	100
Europium-149	100	Terbium-155	1,000
Europium-150 (12.62 h)	100	Terbium-156m (5.0 h)	1,000
Europium-150 (34.2 y)	1	Terbium-156m (24.4 h)	1,000
Europium-152m	100	Terbium-156	100
Europium-152	1	Terbium-157	10
Europium-154	1	Terbium-158	1
Europium-155	10	Terbium-160	10
Europium-156	100	Terbium-161	100
Europium-157	100	Dysprosium-155	1,000
Europium-158	1,000	Dysprosium-157	1,000
Gadolinium-145	1,000	Dysprosium-159	100
Gadolinium-146	10	Dysprosium-165	1,000
Gadolinium-147	100	Dysprosium-166	100
Gadolinium-148	0.001	Holmium-155	1,000
Gadolinium-149	100	Holmium-157	1,000
Gadolinium-151	10	Holmium-159	1,000
Gadolinium-152	100	Holmium-161	1,000
Gadolinium-153	10	Holmium-162m	1,000
Gadolinium-159	100	Holmium-162	1,000
Terbium-147	1,000	Holmium-164m	1,000
Terbium-149	100	Holmium-164	1,000
Terbium-150	1,000	Holmium-166m	1
Terbium-151	100	Holmium-166	100
Terbium-153	1,000	Holmium-167	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Erbium-161	1,000	Thulium-172	100
Erbium-165	1,000	Thulium-173	100
Erbium-169	100	Thulium-175	1,000
Erbium-171	100	Ytterbium-162	1,000
Erbium-172	100	Ytterbium-166	100
Thulium-162	1,000	Ytterbium-167	1,000
Thulium-166	100	Ytterbium-169	100
Thulium-167	100	Ytterbium-175	100
Thulium-170	10	Ytterbium-177	1,000
Thulium-171	10	Ytterbium-178	1,000
Lutetium-169	100	Tantalum-174	1,000
Lutetium-170	100	Tantalum-175	1,000
Lutetium-171	100	Tantalum-176	100
Lutetium-172	100	Tantalum-177	1,000
Lutetium-173	10	Tantalum-178	1,000
Lutetium-174m	10	Tantalum-179	100
Lutetium-174	10	Tantalum-180m	1,000
Lutetium-176m	1,000	Tantalum-180	100
Lutetium-176	100	Tantalum-182m	1,000
Lutetium-177m	10	Tantalum-182	10
Lutetium-177	100	Tantalum-183	100
Lutetium-178m	1,000	Tantalum-184	100
Lutetium-178	1,000	Tantalum-185	1,000
Lutetium-179	1,000	Tantalum-186	1,000
Hafnium-170	100	Tungsten-176	1,000
Hafnium-172	1	Tungsten-177	1,000
Hafnium-173	1,000	Tungsten-178	1,000
Hafnium-175	100	Tungsten-179	1,000
Hafnium-177m	1,000	Tungsten-181	1,000
Hafnium-178m	0.1	Tungsten-185	100
Hafnium-179m	10	Tungsten-187	100
Hafnium-180m	1,000	Tungsten-188	10
Hafnium-181	10	Rhenium-177	1,000
Hafnium-182m	1,000	Rhenium-178	1,000
Hafnium-182	0.1	Rhenium-181	1,000
Hafnium-183	1,000	Rhenium-182 (12.7 h)	1,000
Hafnium-184	100	Rhenium-182 (64.O h)	100
Tantalum-172	1,000	Rhenium-184m	10
Tantalum-173	1,000	Rhenium-184	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Rhenium-186m	10	Osmium-180	1,000
Rhenium-186	100	Osmium-181	1,000
Rhenium-187	1,000	Osmium-182	100
Rhenium-188m	1,000	Osmium-185	100
Rhenium-188	100	Osmium-189m	1,000
Rhenium-189	100	Osmium-191m	1,000
Osmium-191	100	Gold-198	100
Osmium-193	100	Gold-199	100
Osmium-194	1	Gold-200m	100
Iridium-182	1,000	Gold-200	1,000
Iridium-184	1,000	Gold-201	1,000
Iridium-185	1,000	Mercury-193m	100
Iridium-186	100	Mercury-193	1,000
Iridium-187	1,000	Mercury-194	1
Iridium-188	100	Mercury-195m	100
Iridium-189	100	Mercury-195	1,000
Iridium-190m	1,000	Mercury-197m	100
Iridium-190	100	Mercury-197	1,000
Iridium-192m (1.4 min)	10	Mercury-199m	1,000
Iridium-192 (73.8 d)	1	Mercury-203	100
Iridium-194m	10	Thallium-194m	1,000
Iridium-194	100	Thallium-194	1,000
Iridium-195m	1,000	Thallium-195	1,000
Iridium-195	1,000	Thallium-197	1,000
Platinum-186	1,000	Thallium-198m	1,000
Platinum-188	100	Thallium-198	1,000
Platinum-189	1,000	Thallium-199	1,000
Platinum-191	100	Thallium-201	1,000
Platinum-193m	100	Thallium-200	1,000
Platinum-193	1,000	Thallium-202	100
Platinum-195m	100	Thallium-204	100
Platinum-197m	1,000	Lead-195m	1,000
Platinum-197	100	Lead-198	1,000
Platinum-199	1,000	Lead-199	1,000
Platinum-200	100	Lead-200	100
Gold-193	1,000	Lead-201	1,000
Gold-194	100	Lead-202m	1,000
Gold-195	10	Lead-202	10
Gold-198m	100	Lead-203	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Lead-205	100	Lead-210	0.01
Lead-209	1,000	Lead-211	100
Lead-212	1	Thorium-226	10
Lead-214	100	Thorium-227	0.01
Bismuth-200	1,000	Thorium-228	0.001
Bismuth-201	1,000	Thorium-229	0.001
Bismuth-202	1,000	Thorium-230	0.001
Bismuth-203	100	Thorium-231	100
Bismuth-205	100	Thorium-232	100
Bismuth-206	100	Thorium-234	10
Bismuth-207	10	Thorium-natural	100
Bismuth-210m	0.1	Protactinium-227	10
Bismuth-210	1	Protactinium-228	1
Bismuth-212	10	Protactinium-230	0.1
Bismuth-213	10	Protactinium-231	0.001
Bismuth-214	100	Protactinium-232	1
Polonium-203	1,000	Protactinium-233	100
Polonium-205	1,000	Protactinium-234	100
Polonium-207	1,000	Uranium-230	0.01
Polonium-210	0.1	Uranium-231	100
Astatine-207	100	Uranium-232	0.001
Astatine-211	10	Uranium-233	0.001
Radon-220	1	Uranium-234	0.001
Radon-222	1	Uranium-235	0.001
Francium-222	100	Uranium-236	0.001
Francium-223	100	Uranium-237	100
Radium-223	0.1	Uranium-238	100
Radium-224	0.1	Uranium-239	1,000
Radium-225	0.1	Uranium-240	100
Radium-226	0.1	Uranium-natural	100
Radium-227	1,000	Neptunium-232	100
Radium-228	0.1	Neptunium-233	1,000
Actinium-224	1	Neptunium-234	100
Actinium-225	0.01	Neptunium-235	100
Actinium-226	0.1	Neptunium-236 (1.15E+5 y)	0.001
Actinium-227	0.001	Neptunium-236 (22.5 h)	1
Actinium-228	1	Neptunium-237	0.001
Neptunium-238	10	Neptunium-240	1,000
Neptunium-239	100	Plutonium-234	10

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Plutonium-235	1,000	Berkelium-250	10
Plutonium-236	0.001	Californium-244	100
Plutonium-237	100	Californium-246	1
Plutonium-238	0.001	Californium-248	0.01
Plutonium-239	0.001	Californium-249	0.001
Plutonium-240	0.001	Californium-250	0.001
Plutonium-241	0.01	Californium-251	0.001
Plutonium-242	0.001	Californium-252	0.001
Plutonium-243	1,000	Californium-253	0.1
Plutonium-244	0.001	Californium-254	0.001
Plutonium-245	100	Einsteinium-250	100
Americium-237	1,000	Einsteinium-251	100
Americium-238	100	Einsteinium-253	0.1
Americium-239	1,000	Einsteinium-254m	1
Americium-240	100	Einsteinium-254	0.01
Americium-241	0.001	Fermium-252	1
Americium-242m	0.001	Fermium-253	1
Americium-242	10	Fermium-254	10
Americium-243	0.001	Fermium-255	1
Americium-244m	100	Fermium-257	0.01
Americium-244	10	Mendelevium-257	10
Americium-245	1,000	Mendelevium-258	0.01
Americium-246m	1,000		
Americium-246	1,000		
Curium-238	100		
Curium-240	0.1		
Curium-241	1		
Curium-242	0.01		
Curium-243	0.001		
Curium-244	0.001		
Curium-245	0.001		
Curium-246	0.001		
Curium-247	0.001		
Curium-248	0.001		
Curium-249	1,000		
Berkelium-245	100		
Berkelium-246	100		
Berkelium-247	0.001		
Berkelium-249	0.1		

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

NOTE: For purposes of D.902e., D.905a., and D.1201a. where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" -- that is, unity.

[a/] *The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of Appendix B to Part D, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

Appendix D (reserved)

Appendix E (reserved)

PART D

Attachment to **APPENDIX G**

CLASSIFICATION AND CHARACTERISTICS OF LOW-LEVEL RADIOACTIVE WASTE

Section I. - Classification of Radioactive Waste for Land Disposal.

(a) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(b) Classes of waste.

(1) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in Section II.(a). If Class A waste also meets the stability requirements set forth in Section II.(b), it is not necessary to segregate the waste for disposal.

(2) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in Section II.

(3) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in Section II.

(c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table IV, classification shall be determined as follows:

(1) If the concentration does not exceed 0.1 times the value in Table IV, the waste is Class A.

(2) If the concentration exceeds 0.1 times the value in Table IV, but does not exceed the value in Table IV, the waste is Class C.

(3) If the concentration exceeds the value in Table IV, the waste is not generally acceptable for land disposal.

(4) For wastes containing mixtures of radionuclides listed in Table IV, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE IV

Radionuclide	Concentration Curie/Cubic Meter[a/]	Concentration Nanocurie/Gram[b/]
C-14	8	
C-14 in activated metal	80	
Ni-59 in activated metal	220	
Nb-94 in activated metal	0.2	
Tc-99	3	
I-129	0.08	
Alpha emitting transuranic radionuclides with half-life greater than five years		100
Pu-241		3,500
Cm-242		20,000
Ra-226		100

[a/] *To convert the Ci/m^3 values to gigabecquerel (GBq) per cubic meter, multiply the Ci/m^3 value by 37.*

[b/] *To convert the nCi/g values to becquerel (Bq) per gram, multiply the nCi/g value by 37.*

(d) Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table IV, classification shall be determined based on the concentrations shown in Table V. However, as specified in Section I.(f), if radioactive waste does not contain any nuclides listed in either Table IV or V, it is Class A.

(1) If the concentration does not exceed the value in Column 1, the waste is Class A.

(2) If the concentration exceeds the value in Column 1 but does not exceed the value in Column 2, the waste is Class B.

(3) If the concentration exceeds the value in Column 2 but does not exceed the value in Column 3, the waste is Class C.

(4) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(5) For wastes containing mixtures of the radionuclides listed in Table V, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE V

Radionuclide	Concentration Column 1	Curie/Cubic Meter[a/] Column 2	Column 3
Total of all radio-nuclides with less than 5-year half-life	700	*	*
H-3	40	*	*
Co-60	700	*	*
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[a/] *AGENCY NOTE: To convert the Ci/m^3 value to gigabecquerel (GBq) per cubic meter, multiply the Ci/m^3 value by 37. There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other radionuclides in Table V determine the waste to be Class C independent of these radionuclides.*

(e) Classification determined by both long- and short-lived radionuclides. If the radioactive waste contains a mixture of radionuclides, some of which are listed in Table IV and some of which are listed in Table V, classification shall be determined as follows:

(1) If the concentration of a radionuclide listed in Table IV is less than 0.1 times the value listed in Table IV, the class shall be that determined by the concentration of radionuclides listed in Table V.

(2) If the concentration of a radionuclide listed in Table IV exceeds 0.1 times the value listed in Table IV, but does not exceed the value in Table IV, the waste shall be Class C, provided the concentration of radionuclides listed in Table V does not exceed the value shown in Column 3 of Table V.

(f) Classification of wastes with radionuclides other than those listed in Tables IV and V. If the waste does not contain any radionuclides listed in either Table IV or V, it is Class A.

(g) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclide's concentration by the appropriate limit and adding

the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 1.85 TBq/m^3 (50 Ci/m^3) and Cs-137 in a concentration of 814 GBq/m^3 (22 Ci/m^3). Since the concentrations both exceed the values in Column 1, Table V, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33., for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

(h) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as becquerel (nanocurie) per gram.

Section II. - Radioactive Waste Characteristics.

(a) The following are minimum requirements for all classes of waste and are intended to facilitate handling and provide protection of health and safety of personnel at the disposal site.

(1) Wastes shall be packaged in conformance with the conditions of the license issued to the site operator to which the waste will be shipped. Where the conditions of the site license are more restrictive than the provisions of Part D, the site license conditions shall govern.

(2) Wastes shall not be packaged for disposal in cardboard or fiberboard boxes.

(3) Liquid waste shall be packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(4) Solid waste containing liquid shall contain as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume.

(5) Waste shall not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(6) Waste shall not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with Section II.(a)(8).

(7) Waste must not be pyrophoric. Pyrophoric materials contained in wastes shall be

treated, prepared, and packaged to be nonflammable.[****/]

(8) Wastes in a gaseous form shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at 20°C. Total activity shall not exceed 3.7 TBq (100 Ci) per container.

(9) Wastes containing hazardous, biological, pathogenic, or infectious material shall be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in Section II.(a)(3) and (4), liquid wastes, or wastes containing liquid, shall be converted into a form that contains as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5 percent of the volume of the waste for waste processed to a stable form.

(3) Void spaces within the waste and between the waste and its package shall be reduced to the extent practicable.

Section III. - Labeling.

Each package of waste shall be clearly labeled to identify whether it is Class A, Class B, or Class C waste, in accordance with Section I.

[****/] *See. A.4 of these regulations for definition of pyrophoric material.*

3. If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

4. If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (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 DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC} SUBB + \frac{C_C}{DAC_C} \leq 1$$

Part D

Appendix C

QUANTITIES[a] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

Radionuclide	Quantity (μCi)[b]	Radionuclide	Quantity (μCi)[b]
Hydrogen-3	1,000	Scandium-47	100
Beryllium-7	1,000	Scandium-48	100
Beryllium-10	1	Scandium-49	1,000
Carbon-11	1,000	Titanium-44	1
Carbon-14	100	Titanium-45	1,000
Fluorine-18	1,000	Vanadium-47	1,000
Sodium-22	10	Vanadium-48	100
Sodium-24	100	Vanadium-49	1,000
Magnesium-28	100	Chromium-48	1,000
Aluminum-26	10	Chromium-49	1,000
Silicon-31	1,000	Chromium-51	1,000
Silicon-32	1	Manganese-51	1,000
Phosphorus-32	10	Manganese-52m	1,000
Phosphorus-33	100	Manganese-52	100
Sulfur-35	100	Manganese-53	1,000
Chlorine-36	10	Manganese-54	100
Chlorine-38	1,000	Manganese-56	1,000
Chlorine-39	1,000	Iron-52	100
Argon-39	1,000	Iron-55	100
Argon-41	1,000	Iron-59	10
Potassium-40	100	Iron-60	1
Potassium-42	1,000	Cobalt-55	100
Potassium-43	1,000	Cobalt-56	10
Potassium-44	1,000	Cobalt-57	100
Potassium-45	1,000	Cobalt-58m	1,000
Calcium-41	100	Cobalt-58	100
Calcium-45	100	Cobalt-60m	1,000
Calcium-47	100	Cobalt-60	1
Scandium-43	1,000	Cobalt-61	1,000
Scandium-44m	100	Cobalt-62m	1,000
Scandium-44	100	Nickel-56	100
Scandium-46	10	Nickel-57	100
Nickel-59	100	Nickel-63	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Nickel-65	1,000	Arsenic-76	100
Nickel-66	10	Arsenic-77	100
Copper-60	1,000	Arsenic-78	1,000
Copper-61	1,000	Selenium-70	1,000
Copper-64	1,000	Selenium-73m	1,000
Copper-67	1,000	Selenium-73	100
Zinc-62	100	Selenium-75	100
Zinc-63	1,000	Selenium-79	100
Zinc-65	10	Selenium-81m	1,000
Zinc-69m	100	Selenium-81	1,000
Zinc-69	1,000	Selenium-83	1,000
Zinc-71m	1,000	Bromine-74m	1,000
Zinc-72	100	Bromine-74	1,000
Gallium-65	1,000	Bromine-75	1,000
Gallium-66	100	Bromine-76	100
Gallium-67	1,000	Bromine-77	1,000
Gallium-68	1,000	Bromine-80m	1,000
Gallium-70	1,000	Bromine-80	1,000
Gallium-72	100	Bromine-82	100
Gallium-73	1,000	Bromine-83	1,000
Germanium-66	1,000	Bromine-84	1,000
Germanium-67	1,000	Krypton-74	1,000
Germanium-68	10	Krypton-76	1,000
Germanium-69	1,000	Krypton-77	1,000
Germanium-71	1,000	Krypton-79	1,000
Germanium-75	1,000	Krypton-81	1,000
Germanium-77	1,000	Krypton-83m	1,000
Germanium-78	1,000	Krypton-85m	1,000
Arsenic-69	1,000	Krypton-85	1,000
Arsenic-70	1,000	Krypton-87	1,000
Arsenic-71	100	Krypton-88	1,000
Arsenic-72	100	Rubidium-79	1,000
Arsenic-73	100	Rubidium-81m	1,000
Arsenic-74	100	Rubidium-81	1,000
Rubidium-82m	1,000	Rubidium-88	1,000
Rubidium-83	100	Rubidium-89	1,000
Rubidium-84	100	Strontium-80	100
Rubidium-86	100	Strontium-81	1,000
Rubidium-87	100	Strontium-83	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Strontium-85m	1,000	Niobium-94	1
Strontium-85	100	Niobium-95m	100
Strontium-87m	1,000	Niobium-95	100
Strontium-89	10	Niobium-96	100
Strontium-90	0.1	Niobium-97	1,000
Strontium-91	100	Niobium-98	1,000
Strontium-92	100	Molybdenum-90	100
Yttrium-86m	1,000	Molybdenum-93m	100
Yttrium-86	100	Molybdenum-93	10
Yttrium-87	100	Molybdenum-99	100
Yttrium-88	10	Molybdenum-101	1,000
Yttrium-90m	1,000	Technetium-93m	1,000
Yttrium-90	10	Technetium-93	1,000
Yttrium-91m	1,000	Technetium-94m	1,000
Yttrium-91	10	Technetium-94	1,000
Yttrium-92	100	Technetium-96m	1,000
Yttrium-93	100	Technetium-96	100
Yttrium-94	1,000	Technetium-97m	100
Yttrium-95	1,000	Technetium-97	1,000
Zirconium-86	100	Technetium-98	10
Zirconium-88	10	Technetium-99m	1,000
Zirconium-89	100	Technetium-99	100
Zirconium-93	1	Technetium-101	1,000
Zirconium-95	10	Technetium-104	1,000
Zirconium-97	100	Ruthenium-94	1,000
Niobium-88	1,000	Ruthenium-97	1,000
Niobium-89m (66 min)	1,000	Ruthenium-103	100
Niobium-89 (122 min)	1,000	Ruthenium-105	1,000
Niobium-90	100	Ruthenium-106	1
Niobium-93m	10	Rhodium-99m	1,000
Rhodium-99	100	Rhodium-107	1,000
Rhodium-100	100	Palladium-100	100
Rhodium-101m	1,000	Palladium-101	1,000
Rhodium-101	10	Palladium-103	100
Rhodium-102m	10	Palladium-107	10
Rhodium-102	10	Palladium-109	100
Rhodium-103m	1,000	Silver-102	1,000
Rhodium-105	100	Silver-103	1,000
Rhodium-106m	1,000	Silver-104m	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Silver-104	1,000	Tin-123	10
Silver-105	100	Tin-125	10
Silver-106m	100	Tin-126	10
Silver-106	1,000	Tin-127	1,000
Silver-108m	1	Tin-128	1,000
Silver-11Om	10	Antimony-115	1,000
Silver-111	100	Antimony-116m	1,000
Silver-112	100	Antimony-116	1,000
Silver-115	1,000	Antimony-117	1,000
Cadmium-104	1,000	Antimony-118m	1,000
Cadmium-107	1,000	Antimony-119	1,000
Cadmium-109	1	Antimony-120 (16 min)	1,000
Cadmium-113m	0.1	Antimony-120 (5.76 d)	100
Cadmium-113	100	Antimony-122	100
Cadmium-115m	10	Antimony-124m	1,000
Cadmium-115	100	Antimony-124	10
Cadmium-117m	1,000	Antimony-125	100
Cadmium-117	1,000	Antimony-126m	1,000
Indium-109	1,000	Antimony-126	100
Indium-110 (69.1 min)	1,000	Antimony-127	100
Indium-11O (4.9 h)	1,000	Antimony-128 (10.4 min)	1,000
Indium-111	100	Antimony-128 (9.O1 h)	100
Indium-112	1,000	Antimony-129	100
Indium-113m	1,000	Antimony-130	1,000
Indium-114m	10	Antimony-131	1,000
Indium-115m	1,000	Tellurium-116	1,000
Indium-115	100	Tellurium-121m	10
Indium-116m	1,000	Tellurium-121	100
Indium-117m	1,000	Tellurium-123m	10
Indium-117	1,000	Tellurium-123	100
Indium-119m	1,000	Tellurium-125m	10
Tin-110	100	Tellurium-127m	10
Tin-111	1,000	Tellurium-127	1,000
Tin-113	100	Tellurium-129m	10
Tin-117m	100	Tellurium-129	1,000
Tin-119m	100	Tellurium-131m	10
Tin-121m	100	Tellurium-131	100
Tin-121	1,000	Tellurium-132	10
Tin-123m	1,000	Tellurium-133m	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Tellurium-133	1,000	Xenon-125	1,000
Tellurium-134	1,000	Xenon-127	1,000
Iodine-120m	1,000	Xenon-129m	1,000
Iodine-120	100	Xenon-131m	1,000
Iodine-121	1,000	Xenon-133m	1,000
Iodine-123	100	Xenon-133	1,000
Iodine-124	10	Xenon-135m	1,000
Iodine-125	1	Xenon-135	1,000
Iodine-126	1	Xenon-138	1,000
Iodine-128	1,000	Cesium-125	1,000
Iodine-129	1	Cesium-127	1,000
Iodine-130	10	Cesium-129	1,000
Iodine-131	1	Cesium-130	1,000
Iodine-132m	100	Cesium-131	1,000
Iodine-132	100	Cesium-132	100
Iodine-133	10	Cesium-134m	1,000
Iodine-134	1,000	Cesium-134	10
Iodine-135	100	Cesium-135m	1,000
Xenon-120	1,000	Cesium-135	100
Xenon-121	1,000	Cesium-136	10
Xenon-122	1,000	Cesium-137	10
Xenon-123	1,000	Cesium-138	1,000
Barium-126	1,000	Lanthanum-141	100
Barium-128	100	Lanthanum-142	1,000
Barium-131m	1,000	Lanthanum-143	1,000
Barium-131	100	Cerium-134	100
Barium-133m	100	Cerium-135	100
Barium-133	100	Cerium-137m	100
Barium-135m	100	Cerium-137	1,000
Barium-139	1,000	Cerium-139	100
Barium-140	100	Cerium-141	100
Barium-141	1,000	Cerium-143	100
Barium-142	1,000	Cerium-144	1
Lanthanum-131	1,000	Praseodymium-136	1,000
Lanthanum-132	100	Praseodymium-137	1,000
Lanthanum-135	1,000	Praseodymium-138m	1,000
Lanthanum-137	10	Praseodymium-139	1,000
Lanthanum-138	100	Praseodymium-142m	1,000
Lanthanum-140	100	Praseodymium-142	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Praseodymium-143	100	Promethium-148m	10
Praseodymium-144	1,000	Promethium-148	10
Praseodymium-145	100	Promethium-149	100
Praseodymium-147	1,000	Promethium-150	1,000
Neodymium-136	1,000	Promethium-151	100
Neodymium-138	100	Samarium-141m	1,000
Neodymium-139m	1,000	Samarium-141	1,000
Neodymium-139	1,000	Samarium-142	1,000
Neodymium-141	1,000	Samarium-145	100
Neodymium-147	100	Samarium-146	1
Neodymium-149	1,000	Samarium-147	100
Neodymium-151	1,000	Samarium-151	10
Promethium-141	1,000	Samarium-153	100
Promethium-143	100	Samarium-155	1,000
Promethium-144	10	Samarium-156	1,000
Promethium-145	10	Europium-145	100
Promethium-146	1	Europium-146	100
Promethium-147	10	Europium-147	100
Europium-148	10	Terbium-149	100
Europium-149	100	Terbium-150	1,000
Europium-150 (12.62 h)	100	Terbium-151	100
Europium-150 (34.2 y)	1	Terbium-153	1,000
Europium-152m	100	Terbium-154	100
Europium-152	1	Terbium-155	1,000
Europium-154	1	Terbium-156m (5.O h)	1,000
Europium-155	10	Terbium-156m (24.4 h)	1,000
Europium-156	100	Terbium-156	100
Europium-157	100	Terbium-157	10
Europium-158	1,000	Terbium-158	1
Gadolinium-145	1,000	Terbium-160	10
Gadolinium-146	10	Terbium-161	100
Gadolinium-147	100	Dysprosium-155	1,000
Gadolinium-148	0.001	Dysprosium-157	1,000
Gadolinium-149	100	Dysprosium-159	100
Gadolinium-151	10	Dysprosium-165	1,000
Gadolinium-152	100	Dysprosium-166	100
Gadolinium-153	10	Holmium-155	1,000
Gadolinium-159	100	Holmium-157	1,000
Terbium-147	1,000	Holmium-159	1,000

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Holmium-161	1,000	Thulium-166	100
Holmium-162m	1,000	Thulium-167	100
Holmium-162	1,000	Thulium-170	10
Holmium-164m	1,000	Thulium-171	10
Holmium-164	1,000	Thulium-172	100
Holmium-166m	1	Thulium-173	100
Holmium-166	100	Thulium-175	1,000
Holmium-167	1,000	Ytterbium-162	1,000
Erbium-161	1,000	Ytterbium-166	100
Erbium-165	1,000	Ytterbium-167	1,000
Erbium-169	100	Ytterbium-169	100
Erbium-171	100	Ytterbium-175	100
Erbium-172	100	Ytterbium-177	1,000
Thulium-162	1,000	Ytterbium-178	1,000
Lutetium-169	100	Hafnium-183	1,000
Lutetium-170	100	Hafnium-184	100
Lutetium-171	100	Tantalum-172	1,000
Lutetium-172	100	Tantalum-173	1,000
Lutetium-173	10	Tantalum-174	1,000
Lutetium-174m	10	Tantalum-175	1,000
Lutetium-174	10	Tantalum-176	100
Lutetium-176m	1,000	Tantalum-177	1,000
Lutetium-176	100	Tantalum-178	1,000
Lutetium-177m	10	Tantalum-179	100
Lutetium-177	100	Tantalum-180m	1,000
Lutetium-178m	1,000	Tantalum-180	100
Lutetium-178	1,000	Tantalum-182m	1,000
Lutetium-179	1,000	Tantalum-182	10
Hafnium-170	100	Tantalum-183	100
Hafnium-172	1	Tantalum-184	100
Hafnium-173	1,000	Tantalum-185	1,000
Hafnium-175	100	Tantalum-186	1,000
Hafnium-177m	1,000	Tungsten-176	1,000
Hafnium-178m	0.1	Tungsten-177	1,000
Hafnium-179m	10	Tungsten-178	1,000
Hafnium-180m	1,000	Tungsten-179	1,000
Hafnium-181	10	Tungsten-181	1,000
Hafnium-182m	1,000	Tungsten-185	100
Hafnium-182	0.1	Tungsten-187	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Tungsten-188	10	Rhenium-187	1,000
Rhenium-177	1,000	Rhenium-188m	1,000
Rhenium-178	1,000	Rhenium-188	100
Rhenium-181	1,000	Rhenium-189	100
Rhenium-182 (12.7 h)	1,000	Osmium-180	1,000
Rhenium-182 (64.O h)	100	Osmium-181	1,000
Rhenium-184m	10	Osmium-182	100
Rhenium-184	100	Osmium-185	100
Rhenium-186m	10	Osmium-189m	1,000
Rhenium-186	100	Osmium-191m	1,000
Osmium-191	100	Gold-193	1,000
Osmium-193	100	Gold-194	100
Osmium-194	1	Gold-195	10
Iridium-182	1,000	Gold-198m	100
Iridium-184	1,000	Gold-198	100
Iridium-185	1,000	Gold-199	100
Iridium-186	100	Gold-200m	100
Iridium-187	1,000	Gold-200	1,000
Iridium-188	100	Gold-201	1,000
Iridium-189	100	Mercury-193m	100
Iridium-190m	1,000	Mercury-193	1,000
Iridium-190	100	Mercury-194	1
Iridium-192m (1.4 min)	10	Mercury-195m	100
Iridium-192 (73.8 d)	1	Mercury-195	1,000
Iridium-194m	10	Mercury-197m	100
Iridium-194	100	Mercury-197	1,000
Iridium-195m	1,000	Mercury-199m	1,000
Iridium-195	1,000	Mercury-203	100
Platinum-186	1,000	Thallium-194m	1,000
Platinum-188	100	Thallium-194	1,000
Platinum-189	1,000	Thallium-195	1,000
Platinum-191	100	Thallium-197	1,000
Platinum-193m	100	Thallium-198m	1,000
Platinum-193	1,000	Thallium-198	1,000
Platinum-195m	100	Thallium-199	1,000
Platinum-197m	1,000	Thallium-201	1,000
Platinum-197	100	Thallium-200	1,000
Platinum-199	1,000	Thallium-202	100
Platinum-200	100	Thallium-204	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Lead-195m	1,000	Lead-202	10
Lead-198	1,000	Lead-203	1,000
Lead-199	1,000	Lead-205	100
Lead-200	100	Lead-209	1,000
Lead-201	1,000	Lead-210	0.01
Lead-202m	1,000	Lead-211	100
Lead-212	1	Actinium-227	0.001
Lead-214	100	Actinium-228	1
Bismuth-200	1,000	Thorium-226	10
Bismuth-201	1,000	Thorium-227	0.01
Bismuth-202	1,000	Thorium-228	0.001
Bismuth-203	100	Thorium-229	0.001
Bismuth-205	100	Thorium-230	0.001
Bismuth-206	100	Thorium-231	100
Bismuth-207	10	Thorium-232	100
Bismuth-210m	0.1	Thorium-234	10
Bismuth-210	1	Thorium-natural	100
Bismuth-212	10	Protactinium-227	10
Bismuth-213	10	Protactinium-228	1
Bismuth-214	100	Protactinium-230	0.1
Polonium-203	1,000	Protactinium-231	0.001
Polonium-205	1,000	Protactinium-232	1
Polonium-207	1,000	Protactinium-233	100
Polonium-210	0.1	Protactinium-234	100
Astatine-207	100	Uranium-230	0.01
Astatine-211	10	Uranium-231	100
Radon-220	1	Uranium-232	0.001
Radon-222	1	Uranium-233	0.001
Francium-222	100	Uranium-234	0.001
Francium-223	100	Uranium-235	0.001
Radium-223	0.1	Uranium-236	0.001
Radium-224	0.1	Uranium-237	100
Radium-225	0.1	Uranium-238	100
Radium-226	0.1	Uranium-239	1,000
Radium-227	1,000	Uranium-240	100
Radium-228	0.1	Uranium-natural	100
Actinium-224	1	Neptunium-232	100
Actinium-225	0.01	Neptunium-233	1,000
Actinium-226	0.1	Neptunium-234	100

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Neptunium-235	100	Neptunium-236 (22.5 h)	1
Neptunium-236 (1.15E+5 y)	0.001	Neptunium-237	0.001
Neptunium-238	10	Curium-248	0.001
Neptunium-239	100	Curium-249	1,000
Neptunium-240	1,000	Berkelium-245	100
Plutonium-234	10	Berkelium-246	100
Plutonium-235	1,000	Berkelium-247	0.001
Plutonium-236	0.001	Berkelium-249	0.1
Plutonium-237	100	Berkelium-250	10
Plutonium-238	0.001	Californium-244	100
Plutonium-239	0.001	Californium-246	1
Plutonium-240	0.001	Californium-248	0.01
Plutonium-241	0.01	Californium-249	0.001
Plutonium-242	0.001	Californium-250	0.001
Plutonium-243	1,000	Californium-251	0.001
Plutonium-244	0.001	Californium-252	0.001
Plutonium-245	100	Californium-253	0.1
Americium-237	1,000	Californium-254	0.001
Americium-238	100	Einsteinium-250	100
Americium-239	1,000	Einsteinium-251	100
Americium-240	100	Einsteinium-253	0.1
Americium-241	0.001	Einsteinium-254m	1
Americium-242m	0.001	Einsteinium-254	0.01
Americium-242	10	Fermium-252	1
Americium-243	0.001	Fermium-253	1
Americium-244m	100	Fermium-254	10
Americium-244	10	Fermium-255	1
Americium-245	1,000	Fermium-257	0.01
Americium-246m	1,000	Mendelevium-257	10
Americium-246	1,000	Mendelevium-258	0.01
Curium-238	100		
Curium-240	0.1		
Curium-241	1		
Curium-242	0.01		
Curium-243	0.001		
Curium-244	0.001		
Curium-245	0.001		
Curium-246	0.001		
Curium-247	0.001		

QUANTITIES[a/] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

NOTE: For purposes of D.902e., D.905a., and D.1201a. where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" – that is, unity.

[a/] *The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of Appendix B to Part D, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

PART D

Appendix D (reserved)

Appendix E (reserved)

[PART D

APPENDIX F

QUANTITIES FOR USE WITH DECOMMISSIONING[a/]

Material	Microcurie[b/]
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

[a/] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

QUANTITIES FOR USE WITH DECOMMISSIONING[a/] *(Continued)*

Material	Microcurie[b/]
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
Florine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	0
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	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

[a/] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

QUANTITIES FOR USE WITH DECOMMISSIONING[a/] *(Continued)*

Material	Microcurie[b/]
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

[a/] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

QUANTITIES FOR USE WITH DECOMMISSIONING[a/] *(Continued)*

Material	Microcurie[b/]
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-11Om	1
Silver-111	100
Sodium-22	1
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulfur -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

[a/] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

QUANTITIES FOR USE WITH DECOMMISSIONING[a] *(Continued)*

Material	Microcurie[b]
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)[c]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural)[d]	100
Uranium-233	0.01
Uranium-234	0.01
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

[a] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*
[b] *To convert μCi to kBq, multiply the μCi value by 37.*
[c] *Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.*
[d] *Based on alpha disintegration rate of U-238, U-234, and U-235.*

QUANTITIES FOR USE WITH DECOMMISSIONING[a/] *(Continued)*

Material	Microcurie[b/]
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

NOTE: Where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" -- that is, unity.]

[a/] *This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the Nuclear Regulatory Commission.*

[b/] *To convert μCi to kBq, multiply the μCi value by 37.*

Appendix G

Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests

I. Manifest

A waste generator, collector, or processor who transports, or offers for transportation, low-level radioactive waste intended for ultimate disposal at a licensed low-level radioactive waste land disposal facility must prepare a Manifest reflecting information requested on applicable Agency Forms XX (Uniform Low-Level Radioactive Waste Manifest (Shipping Paper)) and XY (Uniform Low-Level Radioactive Waste Manifest (Container and Waste Description)) and, if necessary, on an applicable Agency Form XZ (Uniform Low-Level Radioactive Waste Manifest (Manifest Index and Regional Compact Tabulation)). Agency Forms XX and XXA must be completed and must physically accompany the pertinent low-level waste shipment. Upon agreement between shipper and consignee, Agency Forms XY and XYA and XZ and XZA may be completed, transmitted, and stored in electronic media with the capability for producing legible, accurate, and complete records on the respective forms. Licensees are not required by Agency to comply with the manifesting requirements of this part when they ship:

(a) LLW for processing and expect its return (i.e., for storage under their license) prior to disposal at a licensed land disposal facility;

(b) LLW that is being returned to the licensee who is the "waste generator" or "generator," as defined in this part; or

(c) Radioactively contaminated material to a "waste processor" that becomes the processor's "residual waste."

For guidance in completing these forms, refer to the instructions that accompany the forms. Copies of manifests required by this appendix may be legible carbon copies, photocopies, or computer printouts that reproduce the data in the format of the uniform manifest.

Agency Forms XX, XXA, XY, XYA, XZ and XZA, and the accompanying instructions, in hard copy, may be obtained from the [cite appropriate Agency address]

This appendix includes information requirements of the Department of Transportation, as codified in 49 CFR part 172. Information on hazardous, medical, or other waste, required to meet Environmental Protection Agency regulations, as codified in 40 CFR parts 259, 261 or elsewhere, is not addressed in this section, and must be provided on the required EPA forms. However, the required EPA forms must accompany the Uniform Low-Level Radioactive Waste Manifest required by this appendix.

As used in this appendix, the following definitions apply:

Agency Forms XX, XXA, XY, XYA, XZ, and XZA are official Agency Forms referenced in this appendix. Licensees need not use originals of these Agency Forms as long as any substitute forms are equivalent to the original documentation in respect to content, clarity, size, and location of information. Upon agreement between the shipper and consignee, Agency Forms XY (and XYA) and Agency Forms XZ (and XZA) may be completed, transmitted, and stored in electronic media. The electronic media must have the capability for producing legible, accurate, and complete records in the format of the uniform manifest.

Chemical description means a description of the principal chemical characteristics of a low-level radioactive waste.

Computer-readable medium means that the regulatory agency's computer can transfer the information from the medium into its memory.

Consignee means the designated receiver of the shipment of low-level radioactive waste.

Decontamination facility means a facility operating under a Commission or Agreement State license whose principal purpose is decontamination of equipment or materials to accomplish recycle, reuse, or other waste management objectives, and, for purposes of this part, is not considered to be a consignee for LLW shipments.

Disposal container means a container principally used to confine low-level radioactive waste during disposal operations at a land disposal facility (also see "high integrity container"). Note that for some shipments, the disposal container may be the transport package.

EPA identification number means the number received by a transporter following application to the Administrator of EPA as required by 40 CFR part 263.

Generator means a licensee operating under a Commission or Agreement State license who (1) is a waste generator as defined in this part, or (2) is the licensee to whom waste can be attributed within the context of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (e.g., waste generated as a result of decontamination or recycle activities).

High integrity container (HIC) means a container commonly designed to meet the structural stability requirements of section V of this appendix, and to meet Department of Transportation requirements for a Type A package.

Land disposal facility means the land, buildings and structures, and equipment, which are intended to be used for the disposal of radioactive wastes. For purposes of this chapter, a "geologic repository" is not considered a "land disposal facility.

Package means the assembly of components necessary to ensure compliance with the packaging requirements of DOT regulations, together with its radioactive contents, as presented for transport.

Physical description means the items called for on Agency Form XY to describe a low-level radioactive waste.

Residual waste means low-level radioactive waste resulting from processing or decontamination activities that cannot be easily separated into distinct batches attributable to specific waste generators. This waste is attributable to the processor or decontamination facility, as applicable.

Shipper means the licensed entity (i.e., the waste generator, waste collector, or waste processor) who offers low-level radioactive waste for transportation, typically consigning this type of waste to a licensed waste collector, waste processor, or land disposal facility operator.

Shipping paper means Agency Form XX and, if required, Agency Form XXA, which includes the information, required by DOT in 49 CFR part 172.

Uniform Low-Level Radioactive Waste Manifest or *uniform manifest* means the combination of Agency Forms XX, XY, and, if necessary, XZ, and their respective continuation sheets as needed, or equivalent.

Waste collector means an entity, operating under a Commission or Agreement State license, whose principal purpose is to collect and consolidate waste generated by others, and to transfer this waste, without processing or repackaging the collected waste, to another licensed waste collector, licensed waste processor, or licensed land disposal facility.

Waste description means the physical, chemical and radiological description of a low-level radioactive waste as called for on Agency Form XY.

Waste generator means an entity, operating under a Commission or Agreement State license, who (1) possesses any material or component that contains radioactivity or is radioactively contaminated for which the licensee foresees no further use, and (2) transfers this material or component to a licensed land disposal facility or to a licensed waste collector or processor for handling or treatment prior to disposal. A licensee performing processing or decontamination services may be a "waste generator" if the transfer of low-level radioactive waste from its facility is defined as "residual waste."

Waste processor means an entity, operating under a Commission or Agreement State license, whose principal purpose is to process, repackage, or otherwise treat low-level radioactive material or waste generated by others prior to eventual transfer of waste to a licensed low-level radioactive waste land disposal facility.

Waste type means a waste within a disposal container having a unique physical description (i.e., a specific waste descriptor code or description; or a waste sorbed on or solidified in a specifically defined media).

Information Requirements

A. General Information

The shipper of the radioactive waste, shall provide the following information on the uniform manifest:

1. The name, facility address, and telephone number of the licensee shipping the waste;

2. An explicit declaration indicating whether the shipper is acting as a waste generator, collector, processor, or a combination of these identifiers for purposes of the manifested shipment; and

3. The name, address, and telephone number, or the name and EPA identification number for the carrier transporting the waste.

B. Shipment Information

The shipper of the radioactive waste shall provide the following information regarding the waste shipment on the uniform manifest:

1. The date of the waste shipment;

2. The total number of packages/disposal containers;

3. The total disposal volume and disposal weight in the shipment;

4. The total radionuclide activity in the shipment;

5. The activity of each of the radionuclides H - 3, C - 14, Tc-99, and I - 129 contained in the shipment; and

6. The total masses of U - 233, U - 235, and plutonium in special nuclear material, and the total mass of uranium and thorium in source material.

C. Disposal Container and Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding the waste and each disposal container of waste in the shipment:

1. An alphabetic or numeric identification that uniquely identifies each disposal container in the shipment;

2. A physical description of the disposal container, including the manufacturer and model of any high integrity container;

3. The volume displaced by the disposal container;

4. The gross weight of the disposal container, including the waste;

5. For waste consigned to a disposal facility, the maximum radiation level at the surface of each disposal container;

6. A physical and chemical description of the waste;

7. The total weight percentage of chelating agent for any waste containing more than 0.1% chelating agent by weight, plus the identity of the principal chelating agent;

8. The approximate volume of waste within a container;

9. The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name;

10. The identities and activities of individual radionuclides contained in each container, the masses of U - 233, U - 235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material. For discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides associated with or contained on these waste types within a disposal container shall be reported;

11. The total radioactivity within each container; and

12. For wastes consigned to a disposal facility, the classification of the waste pursuant to section IV of this appendix. Waste not meeting the structural stability requirements of section V(b) of this appendix must be identified.

D. Uncontainerized Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding a waste shipment delivered without a disposal container:

1. The approximate volume and weight of the waste;

2. A physical and chemical description of the waste;

3. The total weight percentage of chelating agent if the chelating agent exceeds 0.1% by weight, plus the identity of the principal chelating agent;

4. For waste consigned to a disposal facility, the classification of the waste pursuant to section IV. of this appendix. Waste not meeting the structural stability requirements of section V(b) of this appendix must be identified;

5. The identities and activities of individual radionuclides contained in the waste, the masses of U - 233, U - 235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material; and

6. For wastes consigned to a disposal facility, the maximum radiation levels at the surface of the waste.

E. Multi-Generator Disposal Container Information

This section applies to disposal containers enclosing mixtures of waste originating from different generators. (Note: The origin of the LLW resulting from a processor's activities may be attributable to one or more "generators" (including "waste generators") as defined in this part). It also applies to mixtures of wastes shipped in an uncontainerized form, for which portions of the mixture within the

shipment originate from different generators.

1. For homogeneous mixtures of waste, such as incinerator ash, provide the waste description applicable to the mixture and the volume of the waste attributed to each generator.

2. For heterogeneous mixtures of waste, such as the combined products from a large compactor, identify each generator contributing waste to the disposal container, and, for discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides contained on these waste types within the disposal container. For each generator, provide the following:

(a) The volume of waste within the disposal container;

(b) A physical and chemical description of the waste, including the solidification agent, if any;

(c) The total weight percentage of chelating agents for any disposal container containing more than 0.1% chelating agent by weight, plus the identity of the principal chelating agent;

(d) The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name if the media is claimed to meet stability requirements in section V(b) of this appendix; and

(e) Radionuclide identities and activities contained in the waste, the masses of U - 233, U - 235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material if contained in the waste.

II. Certification

An authorized representative of the waste generator, processor, or collector shall certify by signing and dating the shipment manifest that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Agency. A collector in signing the certification is certifying that nothing has been done to the collected waste, which would invalidate the waste generator's certification.

III. Control and Tracking

A. Any licensee or registrant who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1 through 9 of this appendix. Any licensee or registrant who transfers waste to a licensed waste processor for waste treatment or repackaging shall comply with the requirements of paragraphs A.4 through 9 of this appendix. A licensee shall:

1. Prepare all wastes so that the waste is classified according to section IV. of this appendix and meets the waste characteristics requirements in section V. of this appendix;

2. Label each disposal container (or transport package if potential radiation hazards preclude labeling

of the individual disposal container) of waste to identify whether it is Class A waste, Class B waste, Class C waste, or greater then Class C waste, in accordance with section IV. of this appendix;

3. Conduct a quality assurance program to assure compliance with sections IV. and V. of this appendix (the program must include management evaluation of audits);

4. Prepare the Agency Uniform Low-Level Radioactive Waste Manifest as required by this appendix;

5. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either (i) receipt of the manifest precedes the LLW shipment or (ii) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (i) and (ii) is also acceptable;

6. Include Agency Form XX (and Agency Form XXA, if required) with the shipment regardless of the option chosen in paragraph A.5 of this section;

7. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Form XX;

8. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by these regulations; and

9. For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Agency Form XX;

2. Prepare a new manifest to reflect consolidated shipments that meet the requirements of this appendix. The waste collector shall ensure that, for each container of waste in the shipment, the manifest identifies the generator of that container of waste;

3. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either: (i) Receipt of the manifest precedes the LLW shipment or (ii) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (i) and (ii) is also acceptable;

4. Include Agency Form XX (and Agency Form XXA, if required) with the shipment regardless of the option chosen in paragraph B.3 of this appendix;

5. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Form XX;

6. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by these regulations;

7. For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix; and

8. Notify the shipper and the Agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been cancelled.

C. Any licensed waste processor who treats or repackages waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Agency Form XX;

2. Prepare a new manifest that meets the requirements of this appendix. Preparation of the new manifest reflects that the processor is responsible for meeting these requirements. For each container of waste in the shipment, the manifest shall identify the waste generators, the preprocessed waste volume, and the other information as required in paragraph I.E. of this appendix;

3. Prepare all wastes so that the waste is classified according to section IV. of this appendix and meets the waste characteristics requirements in section V. of this appendix;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with sections IV. and VI. of this appendix;

5. Conduct a quality assurance program to assure compliance with sections IV. and V. of this appendix (the program shall include management evaluation of audits);

6. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either: (i) Receipt of the manifest precedes the LLW shipment or (ii) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (i) and (ii) is also acceptable;

7. Include Agency Form XX (and Agency Form XXA, if required) with the shipment regardless of the option chosen in paragraph C.6 of this section;

8. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Form XX;

9. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by these regulations;

10. For any shipment or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with

paragraph E of this appendix; and

11. Notify the shipper and the Agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been cancelled.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within one week of receipt by returning, as a minimum, a signed copy of Agency Form XX to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. If any discrepancy exists between materials listed on the Uniform Low-Level Radioactive Waste Manifest and materials received, copies or electronic transfer of the affected forms must be returned indicating the discrepancy;

2. Maintain copies of all completed manifests and electronically store the information required by this Appendix until the Agency terminates the license; and

3. Notify the shipper and the Agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been cancelled.

E. Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the Agency. Each licensee who conducts a trace investigation shall file a written report with the Agency within 2 weeks of completion of the investigation.

IV. Classification of Waste

(a) Classification of waste for near surface disposal. (1) *Considerations*. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(2) *Classes of waste*. (i) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in V.(a) of this appendix. If Class A waste also meets the stability requirements set forth in V.(b) of this appendix, it is not necessary to segregate the waste for disposal.

(ii) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in section V of this appendix.

(iii) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in section V of this appendix.

(iv) Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in 10 CFR part 60 unless proposals for disposal of such waste in a disposal site licensed pursuant to 10 CFR Part 61 are approved by the Nuclear Regulatory Commission.

(3) Classification determined by long-lived radionuclides. If radioactive waste contains only radionuclides listed in Table 1, classification shall be determined as follows:

(i) If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A.

(ii) If the concentration exceeds 0.1 times the value in Table 1 but does not exceed the value in Table 1, the waste is Class C.

(iii) If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal.

(iv) For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions.

Table 1	
Radionuclide	**Concentration curies per cubic meter**
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than 5 years	[1]100
Pu-241	[1]3,500
Cm-242	[1]20,000

[1]Units are nanocuries per gram.

(4) Classification determined by short-lived radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentrations shown in Table 2. However, as specified in paragraph (a)(6) of this section, if radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(i) If the concentration does not exceed the value in Column 1, the waste is Class A.

(ii) If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.

(iii) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

(iv) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(v) For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule.

Table 2			
Radionuclide	**Concentration, curies per cubic meter**		
	Col. 1	**Col. 2**	**Col. 3**
Total of all nuclides with less than 5 year half-life	700	[1]	[1]
H-3	40	[1]	[1]
Co-60	700	[1]	[1]
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[1] There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to the Class C independent of these nuclides.

(5) Classification determined by both long- and short-lived radionuclides. If radioactive waste contains a mixture of radionuclides, some of which are listed in Table 1, and some of which are listed in Table 2, classification shall be determined as follows:

(i) If the concentration of a nuclide listed in Table 1 does not exceed 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides listed in Table 2.

(ii) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 but does not exceed the value in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

(6) Classification of wastes with radionuclides other than those listed in Tables 1 and 2. If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 50 Ci/m^3. and Cs-137 in a concentration of 22 Ci/m^3. Since the concentrations both exceed the values in Column 1, Table 2, they must be compared to Column 2 values. For Sr-90 fraction 50/150=0.33; for Cs-137 fraction, 22/44=0.5; the sum of the fractions=0.83. Since the sum is less than 1.0, the waste is Class B.

(8) *Determination of concentrations in wastes*. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram.

V. Waste characteristics.

(a) The following requirements are minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

(1) Waste must not be packaged for disposal in cardboard or fiberboard boxes.

(2) Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(3) Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

(4) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(5) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with paragraph (a)(7) of this section.

(6) Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.

(7) Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total activity must not exceed 100 curies per container.

(8) Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in V(a)(2) and (3), liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.

(3) Void spaces within the waste and between the waste and its package must be reduced to the extent practicable.

VI. Labeling.

Each package of waste must be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with section IV of this appendix.

PART D

Attachment to **APPENDIX G**

CLASSIFICATION AND CHARACTERISTICS OF LOW-LEVEL RADIOACTIVE WASTE

Section I. - Classification of Radioactive Waste for Land Disposal.

(a) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(b) Classes of waste.

(1) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in Section II.(a). If Class A waste also meets the stability requirements set forth in Section II.(b), it is not necessary to segregate the waste for disposal.

(2) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in Section II.

(3) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in Section II.

(c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table IV, classification shall be determined as follows:

(1) If the concentration does not exceed 0.1 times the value in Table IV, the waste is Class A.

(2) If the concentration exceeds 0.1 times the value in Table IV, but does not exceed the value in Table IV, the waste is Class C.

(3) If the concentration exceeds the value in Table IV, the waste is not generally

acceptable for land disposal.

(4) For wastes containing mixtures of radionuclides listed in Table IV, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE IV

Radionuclide	Concentration Curie/Cubic Meter[a/]	Concentration Nanocurie/Gram[b/]
C-14	8	
C-14 in activated metal	80	
Ni-59 in activated metal	220	
Nb-94 in activated metal	0.2	
Tc-99	3	
I-129	0.08	
Alpha emitting transuranic radionuclides with half-life greater than five years		100
Pu-241		3,500
Cm-242		20,000
Ra-226		100

[a/] *To convert the Ci/m³ values to gigabecquerel (GBq) per cubic meter, multiply the Ci/m³ value by 37.*

[b/] *To convert the nCi/g values to becquerel (Bq) per gram, multiply the nCi/g value by 37.*

(d) Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table IV, classification shall be determined based on the concentrations shown in Table V. However, as specified in Section I.(f), if radioactive waste does not contain any nuclides listed in either Table IV or V, it is Class A.

(1) If the concentration does not exceed the value in Column 1, the waste is Class A.

(2) If the concentration exceeds the value in Column 1 but does not exceed the value in Column 2, the waste is Class B.

(3) If the concentration exceeds the value in Column 2 but does not exceed the value in Column 3, the waste is Class C.

(4) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(5) For wastes containing mixtures of the radionuclides listed in Table V, the total

concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE V

Radionuclide	Concentration Column 1	Curie/Cubic Meter[a/] Column 2	Column 3
Total of all radio-nuclides with less than 5-year half-life	700	*	*
H-3	40	*	*
Co-60	700	*	*
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[a/] *AGENCY NOTE: To convert the Ci/m^3 value to gigabecquerel (GBq) per cubic meter, multiply the Ci/m^3 value by 37. There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other radionuclides in Table V determine the waste to be Class C independent of these radionuclides.*

(e) Classification determined by both long- and short-lived radionuclides. If the radioactive waste contains a mixture of radionuclides, some of which are listed in Table IV and some of which are listed in Table V, classification shall be determined as follows:

(1) If the concentration of a radionuclide listed in Table IV is less than 0.1 times the value listed in Table IV, the class shall be that determined by the concentration of radionuclides listed in Table V.

(2) If the concentration of a radionuclide listed in Table IV exceeds 0.1 times the value listed in Table IV, but does not exceed the value in Table IV, the waste shall be Class C, provided the concentration of radionuclides listed in Table V does not exceed the value shown in Column 3 of Table V.

(f) Classification of wastes with radionuclides other than those listed in Tables IV and V. If the waste does not contain any radionuclides listed in either Table IV or V, it is Class A.

(g) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of

1.85 TBq/m^3 (50 Ci/m^3) and Cs-137 in a concentration of 814 GBq/m^3 (22 Ci/m^3). Since the concentrations both exceed the values in Column 1, Table V, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33., for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

(h) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as becquerel (nanocurie) per gram.

Section II. - Radioactive Waste Characteristics.

(a) The following are minimum requirements for all classes of waste and are intended to facilitate handling and provide protection of health and safety of personnel at the disposal site.

(1) Wastes shall be packaged in conformance with the conditions of the license issued to the site operator to which the waste will be shipped. Where the conditions of the site license are more restrictive than the provisions of Part D, the site license conditions shall govern.

(2) Wastes shall not be packaged for disposal in cardboard or fiberboard boxes.

(3) Liquid waste shall be packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(4) Solid waste containing liquid shall contain as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume.

(5) Waste shall not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(6) Waste shall not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with Section II.(a)(8).

(7) Waste must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.[****/]

(8) Wastes in a gaseous form shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at 20°C. Total activity shall not exceed 3.7 TBq (100 Ci) per

[****/] *See. A.4 of these regulations for definition of pyrophoric material.*

container.

(9) Wastes containing hazardous, biological, pathogenic, or infectious material shall be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in Section II.(a)(3) and (4), liquid wastes, or wastes containing liquid, shall be converted into a form that contains as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5 percent of the volume of the waste for waste processed to a stable form.

(3) Void spaces within the waste and between the waste and its package shall be reduced to the extent practicable.

Section III. - Labeling.

Each package of waste shall be clearly labeled to identify whether it is Class A, Class B, or Class C waste, in accordance with Section I.

2002
RATIONALE FOR REVISIONS

PART D
STANDARDS FOR PROTECTION AGAINST RADIATION

Introduction

This revision to Part D incorporates changes of the revised Part 20 into the *Suggested State Regulations for Control of Radiation.* An accompanying revision to Part A incorporates many of the definitions to Part 20 into the *Suggested State Regulations for Control of Radiation.* Definitions have been added, deleted or amended in Part D to be consistent with the revised Part A where the new or revised terms were used throughout the regulations. Part J was amended to be consistent with the revised 10 CFR Part 19.

Compatibility Requirements

Most of the changes to Part D are compatibility requirements. Compatibility requirements are in an attachment following the draft Parts. The following changes are addressed in this particular update:
60 FR 15649 (Low-Level Waste Shipment Manifest Information & Reporting) eff. date 3/1/98
60 FR 36038 (Radiation Protection Requirements Amended Definitions & Criteria) eff. date 8/14/95
60 FR 48623 (Medical Administration of Radiation & Radioactive Materials) eff. 10/20/95
60 FR 7900 (Freq. of Medical Examination for Use of Respiratory Protection Equip.) eff. date 3/13/95
60 FR 20183 (Standards for Protection Against Radiation; Clarification) eff. date of 4/25/95
61 FR 24669 (Term./Transfer of Licensed Activities: Recordkeeping Requirements) eff. date 6/17/96
61 FR 65120 (Clean Air Act/Resolution of Dual Regulation) eff. date 1/9/97
62 FR 4120 (Criteria for Release of Individuals Administered Radioactive Material) eff. date 5/29/97
62 FR 39058 (Radiological Criteria for license Termination) eff. date 8/20/97
63 FR 39477 (Minor corrections/clarifying changes/minor policy change) eff. date 10/26/98
63 FR 45393 (Minor corrections/clarifying changes/minor policy change) eff. date 10/26/98
63 FR 50127 (Transfer Disposal & Manifests) eff. date 11/20/98
64 FR 54543 (Respiratory Protection & Controls to Restrict Internal Exposure) eff. date 2/2/03
64 FR 55525 (Respiratory Protection & Controls to Restrict Internal Exposure) eff. date 2/2/03

General Provisions

The working group discussed and agreed to renumber the entire Part D to be consistent with all applicable Parts in 10 CFR 20.

In addition to the re-numbering, the following proposed changes are being submitted for review:

D.1001.b. (formerly D.1.b), "in an emergency" was deleted in the last line in order to be consistent with revised 10 CFR 20.1001b.

D.1002 (formerly D.2): language was added to be consistent with 10 CFR 20 after the Release of Patients Administered Radioactive Material change.

D.1003 (formerly D.3):

"Constraint": New definition to be consistent with 10 CFR 20.
"Declared Pregnant Woman": revised to be consistent with 10 CFR 20.
"Dosimetry Processor": revised to be consistent with 10 CFR 20.
"Planned Special Exposure": revised to be consistent with 10 CFR 20.
"Respiratory Protective Device": revised to be consistent with 10 CFR 20.
"Very High Radiation Area": revised to be consistent with 10 CFR 20.

D.1001.b & d (formerly D.101): revised to be consistent with 10 CFR 20.1001

D.1201 (formerly D.201): revised to be consistent with 10 CFR 20.1201

D.1203 (formerly D.203): revised to be consistent with 10 CFR 20.1203

D.1206 (formerly D.206): revised to be consistent with 10 CFR 20.1206

D.1208 (formerly D.208): revised to be consistent with 10 CFR 20.1208

D.1301 (formerly D.301): revised to be consistent with 10 CFR 20.1301

D.1501 (formerly D.501): revised to be consistent with 10 CFR 20.1501

D.1502 (formerly D.502): revised to be consistent with 10 CFR 20.1502

D.1503 (formerly D.503): revised to be consistent with 10 CFR 20.1503

D.1701 (formerly D.701): revised to be consistent with 10 CFR 20.1701

D.1702 (formerly D.702): revised to be consistent with 10 CFR 20.1702

D.1703 (formerly D.703): revised to be consistent with 10 CFR 20.1703

D.1704 (formerly D.704): revised to be consistent with 10 CFR 20.1704

D.1705 (formerly D.705): revised to be consistent with 10 CFR 20.1705

D.1902c (formerly D.902c): revised to allow the words "Grave Danger" to be omitted.

D.1903 (formerly D.903): revised to be consistent with 10 CFR 20.1903

D.2006 (formerly D.1006): revised to be consistent with 10 CFR 20.2006

D.2007 (formerly D.1007): revised to be consistent with 10 CFR 20.2007

D.2101 (formerly D.1101): revised to be consistent with 10 CFR 20.2101

D.2104 (formerly D.1104): removed potential requirement for transfer of records to the Agency.

D.2104 (formerly D.205): revised to be consistent with 10 CFR 20.2104

D.2106 (formerly D.1106): revised to be consistent with 10 CFR 20.2101

D.2202 (formerly D.1202): revised to be consistent with 10 CFR 20.2202

D.2203 (formerly D.1203): revised to be consistent with 10 CFR 20.2203

D.2205 (formerly D.1205): revised to be consistent with 10 CFR 20.2205

D.2208 (formerly D.1208): the working group wanted to make the distinction between working days and calendar days as implied.

APPENDIX A: revised to be consistent with 10 CFR Appendix A

APPENDIX C: revised quantity of C-14 requiring labeling to be consistent with 10 CFR Appendix C

APPENDIX D: deleted when Appendix G became final in 1998.

APPENDIX E: moved to become an attachment to Appendix G

APPENDIX F: deleted when decommissioning rule became final

APPENDIX G: new appendix to be consistent with 10 CFR Appendix G

Matters for Future Consideration

1. The Working Group is considering changing the definition of calendar quarter as follows: "Calendar quarter means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be so arranged such that no day is included in more than one calendar quarter and no day in any one year is omitted from inclusion within a calendar quarter. No licensee or registrant shall change the method observed by him for determining calendar quarters except at the beginning of a year." The change needed is to allow licensees or registrants to begin their year at times other than January as is allowed by the Nuclear Regulatory Commission's definition of "quarter." Note: The term quarter is used with residential quarters in the SSRCR.

2. The Working Group (WG) is considering changing the 0.3 multiplicative factor in the version of D.1201c.ii.(2), which may be higher than necessary, to 0.2, which might be more appropriate, pending recommendations of the National Council on Radiation Protection (NCRP) and Measurements. The WG is also looking at revising the 25% criterion to a value more usable and meaningful by the licensee after reviewing any recommendations from NCRP.

3. The Working Group is considering the selection of an attenuation factor for use for pregnant fluoroscopists, for use in D.1208.

4. The Working Group is considering a method for monitoring personnel eye doses when protective eyewear is worn for use in D.1201.

5. In reference to D.1501c. on accreditation of dosimetry processors by the National Voluntary Laboratory Accreditation Program, the Working Group is considering the matters regarding accident-level accreditation, electronic dosimetry and revising the text to eliminate pocket dosimeters per the previous version of the SSR.

6. The Working Group is considering clarifying the expression "proper visual, communication, and other special capabilities" in D.1703a.vi.

7. The Working Group is considering revising D.2201a. as follows:

a. Telephone Reports. Each licensee or registrant shall report to the Agency by telephone each stolen, lost, or missing source of radiation immediately after its absence becomes known to the licensee or registrant. This requirement does not apply to sources of radiation that are not required to be licensed or registered.

8. The Working Group recommended that specific information required in the report of lost waste shipments in Section III.(e)(2) of Appendix D should be developed.

9. The Working Group is considering removing the bracketed section in D.1202.b.iii to remain consistent with 10 CFR 20.1202. This is currently not in 10 CFR 20. This holds a compatibility designation of "A".

10. The Working Group is considering deleting the wording in D.1801c and adding radiation machines to the list of items a licensee or registrant shall secure from unauthorized removal or access.

11. The Working Group is considering moving sections D.1603 and D.2109 as they pertain only to irradiators and we now have a Part Q, which was written strictly for irradiators. The Group will work closely with the Part Q working group to make this transition.

12. The Working Group is considering amending the decay in storage section (D.2001) to allow decay in storage for any isotope with a half-life of less than 120 days. The WG will work with the SR-6 (Part G) group to combine the decay in storage provision in Part G to that in Part D.

Attachment

Rationale for Proposed Changes to Regulations for Individuals Working in Medical Fluoroscopy
(10/30/92)

Medical fluoroscopic procedures involve exposures of operators and ancillary personnel to scattered x rays and occasionally to primary beam x-rays. Special fluoroscopic procedures are surgical in nature and frequently involve operator irradiation times an order of magnitude larger than routine fluoroscopic procedures. Personnel who perform or assist in fluoroscopic special procedures commonly have collar monitor deep dose equivalent values well in excess of those for routine fluoroscopy, and these annual dose equivalent values are likely to be in excess of 5 rem (0.05 Sv) for full-time angiographers and interventionalists who wear their monitors properly. These values, under the present regulations, cause frequent "overexposure incidents," when in fact the associated effective dose equivalent (H_E) is much lower. *ICRP Publication No. 35* (1982) states:

> In particular, the following advice applies in medical radiology, where the use of lead aprons is common. If a single dosimeter is used it should be worn outside the apron, usually high on the trunk. The recorded result will provide information on the dose equivalent to the skin, eye, and unshielded parts of the body (though not necessarily to the hands) but will overestimate the effective dose equivalent. When the recorded values indicate annual totals approaching dose limits for effective dose equivalent or when realistic estimates of effective dose equivalent are needed as in the optimization of protection, this over-estimation may be unacceptable. Two dosimeters should then be used, one over and one under the protective apron. The interpretation of the combined results will have to depend on the local irradiation conditions and any regulatory requirements.

The proposed changes to the SSRCR presented in D.201c.ii define procedures by which H_E can be determined for special procedures fluoroscopists for whom the current method of overestimating H_E is unacceptable, while excluding personnel who may be working in routine fluoroscopic or radiographic procedures. They also allow the current monitoring system to be used to estimate the eye dose equivalent in D502a.iv(1) and the H_E for routine fluoroscopists in D.201c.ii(1).

Determination of Effective Dose Equivalent for Medical Fluoroscopists

Meinhold has presented the need for reporting personnel doses for external radiation in terms of H_E [Health Physics (1989) 56:4, 570]. Although revisions to 10 CFR Part 20 use the weighting factors recommended by *ICRP Publication No. 26* (1977) and *NCRP Report No. 91* (1987) for the determination of H_E for personnel exposure to internal radiation sources, the Nuclear Regulatory Commission revisions do not yet include the use of the H_E concept for exposure to external radiation sources, because of a lack of "specific recommendations for the use of weighting factors for external dose" [Federal Register (May 21, 1991) 56, 23369]. Nuclear Regulatory Commission regulations apply to exposures from most licensed radioactive sources; but exposures to machine-produced x-rays are not under purview of the Nuclear Regulatory Commission, therefore, such exposures were not explicitly addressed in its rule making for amended Part 20. In the case of the medical fluoroscopy work environment, the situation has been well defined by Faulkner and Harrison in their paper "Estimation of Effective Dose Equivalent to Staff in Diagnostic Radiology." This paper

presents extensive data relating the H_E determined for a Rando phantom "operator" in fluoroscopy as a function of individual monitoring devices worn at unshielded collar and shielded waist locations, for various fluoroscopic peak tube potentials and apron thicknesses [Physics in Medicine and Biology (1988) 33:1, 83-91]. Although these extensive data are determined with the configuration of the x-ray tube over the x-ray table, a related paper by Wøhni and Stranden [Health Physics (36:1,71-73)] allows comparisons between the x-ray tube positioned over and underneath the x-ray table.

The data of Faulkner and Harrison have been further analyzed and reduced by Webster, who has proposed a method of combining data from two individual monitoring devices as a good estimate of H_E [Health Physics (1989) 56:4, 568-9]. This method is given in proposed regulation D.201c.ii(2) for fluoroscopists for whom the recorded deep dose equivalent values indicate annual totals approaching or exceeding the conservative regulation, as recommended by *ICRP Publication No. 35*, quoted above. Specifically, Webster's equation requires the use of deep dose equivalent values for a shielded waist monitor (W) and an unshielded collar monitor (C) to determine H_E with modifying factors which were derived from Faulkner and Harrison's paper:

$H_E = 0.04C + 1.5W.$

The difference between H_E and the "whole body" deep dose equivalent values currently required for fluoroscopists is given as an example. *NCRP Report No. 57* states:

> Exposure of the face and neck will exceed the exposure recorded under the apron by factors between 6 and 25.

Therefore, an unshielded collar badge deep dose equivalent of C equal to 1 rem (0.01 Sv) in one month (a large value for routine fluoroscopists, but not uncommon for special procedures fluoroscopists), would be associated with a shielded waist badge deep dose equivalent of W equal to 40--167 mrem (0.4--1.67 mSv). Using Webster's equation, the H_E for that month is calculated to be

$H_E = 0.04\ (1000) + 1.5\ (40 \text{ to } 167)$ mrem; $= 40 + (60 \text{ to } 250)$ mrem; $= 100$ to 290 mrem.

This H_E annualizes to 1.2--3.48 rem (12--34.8 mSv), significantly below the limit of 5 rem (0.05 Sv). The annual dose equivalent to the eye is calculated to be 12 rem (0.12 Sv), also below the limit of 15 rem (0.15 Sv). A fluoroscopist with an annual collar monitor deep dose equivalent of 12 rem (0.12 Sv) would therefore be expected to have an annual H_E of less than 3.5 rem (35 mSv).

It should be noted that wearing two personal monitoring devices has at least two drawbacks, i.e., the individual may confuse wearing the monitors and inconsistently wear them in the same locations[1/]; and the cost of monitors is doubled. Fluoroscopy personnel who perform or assist in routine fluoroscopic or radiographic procedures do not receive doses sufficiently high to warrant the expense and potential confusion of wearing two badges in order to require a more accurate determination of H_E.

[1/] *Color-coding holders is helpful in minimizing this problem; "yellow belly" for the waist badge is reasonably straightforward! Also using two different types of monitors, such as film and TLD, may be helpful.*

Consistent with *ICRP Publication No. 35*, quoted above, D.201c.ii.(1) allows an overestimate of H_E for some fluoroscopists to be determined from one individual monitoring device, because the overestimate is not burdensome. The criterion to allow calculation of H_E based on the unshielded neck monitor by use of a 0.3 multiplication factor in D.201c.ii(1) is set at 25 percent of the dose limit for the purpose of separating personnel who work in special procedures from personnel who work in routine fluoroscopic or radiographic procedures. The proposed methodology is derived from *NCRP Report No. 57* by using the most conservative value and setting W = C/6 in Webster's equation for H_E. H_E then becomes approximately equal to the unshielded collar badge deep dose equivalent multiplied by 0.3. Comparison of this factor with the data presented in the papers of Faulkner and Harrison, and Wøhni and Stranden indicate that this factor is conservatively low; however, the factor of 0.3 is not believed to be burdensome for the following two reasons:

1. When the collar monitor is used to monitor the dose to the lens of the eye, and the annual lens dose equivalent is limited to 15 rem (0.15 Sv), then the annual effective dose equivalent will not exceed 5 rem (0.05 Sv) annually. In this case, the lens dose equivalent becomes the limitation, rather than the effective dose equivalent.

2. The effective dose equivalent may be estimated by a single collar monitor, but a more accurate estimate is made with both the collar and waist monitors. If a more accurate estimate of H_E is desired, this second option should be used. Therefore, until the National Council on Radiation Protection and Measurements provides definitive guidance for determining H_E, this conservative multiplicative factor of 0.3 may be used when a single collar monitor is worn.

Unlike routine fluoroscopists, special procedures fluoroscopists are likely to have annual collar badge values in excess of 5 rem (0.05 Sv) when they wear their monitors according to current regulations. Since the number of individuals who perform or assist in these types of procedures is much smaller than those in routine fluoroscopy, permitting better training and supervision, both the likelihood of confusing two monitors and the excess costs are minimized. Wearing two monitors has the added benefit of concurrently monitoring gonad dose as well as the dose to a potential embryo/fetus. If these data are needed for personnel in this higher-dose work environment, they are readily available. However, it is proposed that wearing two monitors be <u>required</u> only for declared pregnant women in fluoroscopy so that actual <u>measured</u> values underneath the apron are documented, rather than coarse estimates [D502a.iv(3)].

It is recognized that the monitor worn underneath the apron almost certainly provides an overestimate of the dose received by the embryo/fetus. However, a specific dose reduction factor depends on the individual and the work environment, and a universal dose reduction factor is not recommended without the advice of a qualified expert. Because nearly all personnel have monthly shielded waist monitor values of less than 50 mrem (0.5 mSv), the embryo/fetus dose assessment for specific individuals will be required only in rare circumstances [Brateman L., <u>24th Annual National Conference on Radiation Control</u>, CRCPD Publication 92-5 (1992) 277-9].

Proposed regulation D.201c.ii(1) allows the cumulative H_E for special procedures fluoroscopists to be determined when data are available for only the collar monitor. With the use of a multiplicative factor of 0.3 applied to the unshielded collar badge deep dose equivalent value, an estimate of H_E can be obtained for that portion of the year when only the collar monitor was worn, and this value can

then be summed with values of H_E determined from two monitors when two monitors are worn. Because this provision is applicable only for the situation in which personnel receive large reported doses, it does not apply to personnel who work part-time in radiography and fluoroscopy, who routinely receive lower reported annual doses than 1250 mrem (12.5 mSv): for this group, the use of the 0.3 factor is inappropriate because of the mixed work environment in which a portion of the reported dose might have been received as a whole body dose. In addition, since the current regulations are not burdensome for this group, this practice is consistent with *ICRP Publication No. 35*.

Protective aprons are worn to shield the gonads and a major portion of the trunk and bone marrow of the individual. Therefore, an individual assisting in fluoroscopic procedures with his/her back to the x-ray beam needs to wear appropriate shielding to cover the back, as well as the front, of the chest, abdomen and pelvis, to limit the dose to these organs and tissues. This policy also ensures adequate protection in the case of a declared pregnant woman. Aprons of 0.25 to 0.6 millimeters of lead equivalence were used in the derivation of H_E by Webster in his equation, because these aprons are in common usage. Therefore, F.3a.i(5b) is expanded to provide the appropriate monitoring conditions for the assumptions underlying D.201c.ii.

Proposed modifications to Parts D and F address in particular the monitoring of occupational doses from medical fluoroscopy, and proposed modifications to Part F include the relocation of personnel monitoring issues to Part D. Therefore, F.3a.i.(10) is revised so as to include all of the appropriate sections of Part D, and F.3a.i.(10)(a) is replaced by D.502a.iv and D.201c. Because the requirements for wearing protective aprons in fluoroscopy are included in Part F, and the proposed regulation for locating monitors for determining occupational doses is included in Part D, the definition of protective apron is added to Part A, in accordance with the Conference of Radiation Control Program Directors "Policies and Procedures for the Preparation and Publication of the *Suggested State Regulations* Style Manual."

Conclusion and Summary

Physicians who perform special fluoroscopic procedures frequently receive doses to the head and eyes, which are greater than 5 rem (0.05 Sv) per year. Current regulations consider the largest of these values as the "whole body" dose equivalent, even though the gonads and most of the trunk are shielded by aprons, which provide large protective factors. The incorporation of the recently-revised 10 CFR Part 20 into the SSRCR will exclude the present fallback position of allowing a 5(N-18) rem lifetime whole body dose equivalent for these individuals, and an untenable regulatory situation is likely to occur rapidly. It is already the case that, because the enforcement of current regulations requires frequent censure of personnel performing special fluoroscopic procedures, many personnel do not comply with existing requirements (i.e., wearing unshielded collar badges which have values reported as "whole body" doses). Changing the regulations to these proposed will result in a much more accurate assessment of risk from occupational exposure to radiation and will allow personnel who perform special fluoroscopic procedures to utilize the more up-to-date International Council on Radiation Protection and National Council on Radiation Protection and Measurements effective dose equivalent concept, while continuing to allow adequate regulatory oversight over this specialized work environment.

These proposed regulations are seen as an improvement over existing x-ray regulations and provide a conservative estimate of x-ray exposures in medical fluoroscopy without being unduly restrictive,

burdensome and costly. It is extremely important that these changes be incorporated before unnecessary regulatory problems are created -- that is, incorporated concurrent with the revisions to the SSRCR, which include the Nuclear Regulatory Commission Part 20 modifications.

PART G

USE OF RADIONUCLIDES IN THE HEALING ARTS

General Information

Sec. G.1 - Purpose and Scope. Part G establishes requirements and provisions for the production, preparation, compounding and use of radionuclides in the healing arts and for issuance of licenses authorizing these activities. These requirements and provisions provide for the radiation safety of workers, the general public, patients, and human research subjects. The requirements and provisions of Part G are in addition to, and not in substitution for, others in these regulations unless specifically exempted.

Sec. G.2 - Definitions.

["Accredited institution" means a teaching facility for nuclear medicine technology or radiation therapy technology whose standards are accepted by the United States Department of Education.]

"Address of use" means the building or buildings that are identified on the license and where radioactive material may be produced, prepared, received, used, or stored.

"Area of use" means a portion of an address of use that has been set aside for the purpose of receiving, using, or storing radioactive material.

"Authorized medical physicist" means an individual who:

(1) Meets the requirements in G.26 or G.29; or

(2) Is identified as an authorized medical physicist on a specific medical use license or equivalent permit issued by the Agency, Nuclear Regulatory Commission, Agreement State or Licensing State; or

(3) Is identified as an authorized medical physicist on a permit issued by an Agency, Nuclear Regulatory Commission, Agreement State or Licensing State specific medical use license of broad scope that is authorized to permit the use of radioactive material.

"Authorized nuclear pharmacist" means a pharmacist who:

(1) Meets the requirements in G.27 or G.29; or [and]

(2) Is identified as an authorized nuclear pharmacist on a specific license or equivalent permit that authorizes medical use, the practice of nuclear pharmacy, commercial nuclear pharmacy or the manufacture and distribution of radiopharmaceuticals issued by the Agency, Nuclear Regulatory Commission, Agreement State or Licensing State; or

(3) Is identified as an authorized nuclear pharmacist on a permit issued by an Agency, Nuclear Regulatory Commission, Agreement State or Licensing State specific license of broad scope that is authorized to permit the use of radioactive material.

"Authorized user" means a physician, dentist, or podiatrist who:

(1) Meets the requirements in G.30 and G.46a., G.51a., G.56a., G.57a., G.58a., G.67a., G.68, G.70a., or G.88a.; or

(2) Is identified as an authorized user on a license or equivalent permit issued by the Agency, Nuclear Regulatory Commission, Agreement State or Licensing State; or

(3) Is identified as an authorized user on a permit issued by an Agency, Nuclear Regulatory Commission, Agreement State or Licensing State specific license of broad scope that is authorized to permit the medical use of radioactive material.

"Brachytherapy" means a method of radiation therapy in which plated, embedded, activated, or sealed sources are utilized to deliver a radiation dose at a distance of up to a few centimeters, by surface, intracavitary, intraluminal or interstitial application.

"Brachytherapy source" means a radioactive source or a manufacturer-assembled source train or a combination of these sources that is designed to deliver a therapeutic dose within a distance of a few centimeters.

"Client's address" means the address of use or a temporary jobsite for the purpose of providing mobile medical service in accordance with G.41.

"Dedicated check source" means a radioactive source that is used to assure the consistent response of a radiation detection or measurement device over several months or years.

"Dentist" means an individual licensed to practice dentistry by the state in which the Agency is located.

"Diagnostic clinical procedures manual" means a collection of written procedures that describes each method (and other instructions and precautions) by which the licensee performs diagnostic clinical procedures; where each diagnostic clinical procedure has been approved by the authorized user and includes the radiopharmaceutical, dosage, and route of administration, or in the case of sealed sources for diagnosis, the procedure.

"High dose-rate remote afterloader" (HDR) means a device that remotely delivers a dose rate in excess of 12 gray (1200 rads) per hour at the treatment site.

"Low dose-rate remote afterloader"(LDR) means a device that remotely delivers a dose rate of less than or equal to 2 gray (200 rads) per hour at the treatment site.

"Management" means the chief executive officer or other individual having the authority to manage,

direct, or administer the licensee's activities, or those persons' delegate or delegates.

"Manual brachytherapy" means a type of therapy in which brachytherapy sources are manually applied or inserted.

"Misadministration" means an event that meets the criteria in G.119a.

"Medical institution" means an organization in which several medical disciplines are practiced.

"Medical use" means the intentional internal or external administration of radioactive material or the radiation from radioactive material to patients or human research subjects under the supervision of an authorized user.

"Medium dose-rate remote afterloader" (MDR) means a device that remotely delivers a dose rate of greater than 2 gray (200 rads), but less than, or equal to, 12 gray (1200 rads) per hour at the treatment site.

"Mobile medical service" means the transportation of radioactive material or its medical use at the client's address.

["Nuclear medicine technologist" means an individual who meets the requirements of G.28a. and is under the supervision of an authorized user, to prepare or administer radioactive drugs to patients or human research subjects, or perform *in vivo* or *in vitro* measurements for medical purposes.]

["Nuclear medicine technology" means the science and art of *in vivo* and *in vitro* detection and measurement of radioactivity and the administration of radioactive drugs to patients or human research subjects for diagnostic and therapeutic purposes.]

"Output" means the exposure rate, dose rate, or a quantity related in a known manner to these rates from a brachytherapy source, or a teletherapy, remote afterloader, or gamma stereotactic radiosurgery unit for a specified set of exposure conditions.

"Patient intervention" means actions by the patient or human research subject, whether intentional or unintentional, such as dislodging or removing treatment devices or prematurely terminating the administration.

"Pharmacist" means an individual licensed by the appropriate authority to practice pharmacy in the state in which the Agency is located.

"Physician" means a doctor of medicine or doctor of osteopathy licensed by the appropriate authority to prescribe drugs in the practice of medicine in the state in which the Agency is located.

"Podiatrist" means an individual licensed by the appropriate authority to practice podiatry in the state in which the Agency is located.

"Preceptor" means an individual who provides or directs the training and experience required for an individual to become an authorized user, an authorized medical physicist, an authorized nuclear

pharmacist, [nuclear medicine technologist, radiation therapy technologist] or a Radiation Safety Officer.

"Prescribed dosage" means the specified activity or range of activity of a radioactive drug as documented:

(1) In a written directive as specified in G.22.; or

(2) In accordance with the directions of the authorized user for procedures performed pursuant to G.44, G.47 and G.52.

"Prescribed dose" means:

(1) For gamma stereotactic radiosurgery, the total dose as documented in the written directive;

(2) For teletherapy, the total dose and dose per fraction as documented in the written directive;

(3) For manual brachytherapy, either the total source strength and exposure time or the total dose, as documented in the written directive; or

(4) For remote brachytherapy afterloaders, the total dose and dose per fraction as documented in the written directive.

"Pulsed dose-rate remote afterloader" (PDR) means a special type of remote afterloading device that uses a single source capable of delivering dose rates in the "high dose-rate" range, but:

(1) Is approximately one-tenth of the activity of typical high dose-rate remote afterloader sources; and

(2) Is used to simulate the radiobiology of a low dose rate treatment by inserting the source for a given fraction of each hour.

"Radiation Safety Officer" means an individual who:

(1) Meets the requirements in G.25 or G.29; or

(2) Is identified as a Radiation Safety Officer on a Nuclear Regulatory Commission or Agreement State license or other equivalent permit or license recognized by the Agency for similar types and uses of radioactive material.

["Radiation therapist" means an individual who meets the requirements of G.28b. and is under the supervision of an authorized user to perform procedures and apply radiation emitted from sealed radioactive sources to human beings for therapeutic purposes.]

["Radiation therapy technology" means the science and art of applying radiation emitted from sealed

radioactive sources to patients or human research subjects for therapeutic purposes.]

"Radioactive drug" means any chemical compound containing radioactive material that may be used on or administered to patients or human research subjects as an aid in the diagnosis, treatment, or prevention of disease or other abnormal condition.

"Sealed source" means any radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

"Sealed Source and Device Registry" means the national registry that contains the registration certificates maintained by the Nuclear Regulatory Commission, that summarize the radiation safety information for the sealed sources and devices and describe the licensing and use conditions approved for the product.

"Stereotactic radiosurgery" means the use of external radiation in conjunction with a stereotactic guidance device to precisely deliver a dose to a treatment site.

"Structured educational program" means an educational program designed to impart particular knowledge and practical education through interrelated studies and supervised training.

"Teletherapy" as used in this Part, means a method of radiation therapy in which collimated gamma rays are delivered at a distance from the patient or human research subject.

"Temporary jobsite" as used in this Part, means a location where mobile medical services are conducted other than the location(s) of use authorized on the license.

"Therapeutic dosage" means a dosage of unsealed radioactive material that is intended to deliver a radiation dose to a patient or human research subject for palliative or curative treatment.

"Therapeutic dose" means a radiation dose delivered from a sealed source containing radioactive material to a patient or human research subject for palliative or curative treatment.

"Treatment site" means the anatomical description of the tissue intended to receive a radiation dose, as described in a written directive.

"Type of use" means use of radioactive material as specified under G.44, G.47, G.52, G.59, G.69, G.71 or G.89.

"Unit dosage" means a dosage that:

(1) Is obtained or prepared in accordance with the regulations for uses described in G.44, G.47, or G.52; and

(2) Is to be administered as a single dosage to a patient or human research subject without any further manipulation of the dosage after it is initially prepared.

"Written directive" means an authorized user's written order for the administration of radioactive

material or radiation from radioactive material to a specific patient or human research subject, as specified in G.22.

Sec. G.3 - Maintenance of Records. Each record required by Part G must be legible throughout the retention period specified by each Agency regulation. The record may be the original, a reproduced copy, or a microform provided that the copy or microform is authenticated by authorized personnel and the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

Sec. G.4 - Provisions for Research Involving Human Subjects. A licensee may conduct research involving human subjects using radioactive material provided:

a. That the research is conducted, funded, supported, or regulated by a Federal agency which has implemented the Federal Policy for the Protection of Human Subjects. Otherwise, a licensee shall apply for and receive approval of a specific amendment to its Agency license before conducting such research. Both types of licensees shall, at a minimum, obtain prior informed consent from the human subjects and obtain prior review and approval of the research activities by an "Institutional Review Board" in accordance with the meaning of these terms as defined and described in the Federal Policy for the Protection of Human Subjects;

b. The research involving human subjects authorized in G.4a. shall be conducted using radioactive material authorized for medical use in the license; and

c. Nothing in G.4 relieves licensees from complying with the other requirements in Part G.

Sec. G.5 - U.S. Food and Drug Administration, Federal, and State Requirements. Nothing in this Part relieves the licensee from complying with applicable U.S. Food and Drug Administration, other Federal, and State requirements governing radioactive drugs or devices.

Sec. G.6 - Implementation.

a. A licensee shall implement the provisions in Part G on [insert effective date of the rule].

b. When a requirement in Part G differs from the requirement in an existing license condition, the requirement in this Part shall govern.

c. Any existing license condition that is not affected by a requirement in Part G remains in effect until there is a license amendment or license renewal.

d. If a license condition exempted a licensee from a provision of Part G on [insert effective date of the rule], it will continue to exempt a licensee from the corresponding provision in Part G.

e. If a license condition cites provisions in Part G that will be deleted on [insert effective date of

the rule], then the license condition remains in effect until there is a license amendment or license renewal that modifies or removes this condition.

f. Licensees shall continue to comply with any license condition that requires it to implement procedures required by G.74, G.80, G.81 and G.82 until there is a license amendment or renewal that modifies the license condition.

Sec. G.7 - License Required.

a. A person shall only manufacture, produce, prepare, acquire, receive, possess, use, or transfer radioactive material for medical use in accordance with a specific license issued by the Agency, the Nuclear Regulatory Commission or an Agreement State, or as allowed in G.7b. or G.7c.

b. An individual may receive, possess, use, or transfer radioactive material in accordance with the regulations in Part G under the supervision of an authorized user as provided in G.21, unless prohibited by license condition.

c. An individual may prepare unsealed radioactive material for medical use in accordance with the regulations in Part G under the supervision of an authorized nuclear pharmacist or authorized user as provided in G.21, unless prohibited by license condition.

Sec. G.8 - Application for License, Amendment, or Renewal.

a. An application must be signed by the applicant's or licensee's management.

b. An application for a license for medical use of radioactive material as described in G.44, G.47, G.52, G.59, G.69, G.71 or G.89 must be made by:

   i. Filing an original [and one copy] of [insert Agency application form name], and

   ii. Submitting procedures required by sections G.23, [G.31,] G.74, G.80, G.81 and G.82, as applicable.

c. A request for a license amendment or renewal must be made by:

   i. Submitting an original [and one copy] in letter format.

   ii. Submitting procedures required by sections G.23, [G.31,] G.74 , G.80, G.81 and G.82, as applicable.

d. In addition to the requirements in G.8b. and G.8c., an application for a license or amendment for medical use of radioactive material as described in G.89 of this Part must also include information regarding any radiation safety aspects of the medical use of the material that is not addressed in G.1 through G.43, as well as any specific information on:

   i. Radiation safety precautions and instructions;

ii. Training and experience of proposed users;

iii. Methodology for measurement of dosages or doses to be administered to patients or human research subjects; and

iv. Calibration, maintenance, and repair of instruments and equipment necessary for radiation safety.

e. The applicant or licensee shall also provide any other information requested by the Agency in its review of the application.

f. An applicant that satisfies the requirements specified in C.27b. may apply for a Type A specific license of broad scope.

Sec. G.9 - Mobile Medical Service Administrative Requirements.

a. The Agency shall license mobile medical services or clients of such services. The mobile medical service shall be licensed if the service receives, uses or possesses radioactive material. The client of the mobile medical service shall be licensed if the client receives or possesses radioactive material to be used by a mobile medical service.

b. Mobile medical service licensees shall obtain a letter signed by the management of each location where services are rendered that authorizes use of radioactive material at the client's address of use. This letter shall clearly delineate the authority and responsibility of both the client and the mobile medical service. If the client is licensed, the letter shall document procedures for notification, receipt, storage and documentation of transfer of radioactive material delivered to the client's address for use by the mobile medical service.

c. A mobile medical service shall not have radioactive material delivered directly from the manufacturer or the distributor to the client, unless the client has a license allowing possession of the radioactive material. Radioactive material delivered to the client shall be received and handled in conformance with the client's license.

d. A mobile medical service shall inform the client's management who is on site at each client's address of use at the time that radioactive material is being administered.

e. A licensee providing mobile medical services shall retain the letter required in G.9b. in accordance with G.101.

f. A mobile medical service licensee shall, at a minimum, maintain the following documents on each mobile unit:

i. The current operating and emergency procedures;

ii. A copy of the license;

iii. Copies of the letter required by G.9b.;

iv. Current calibration records for each survey instrument and diagnostic equipment or dose delivery device in use; and

v. Survey records covering uses associated with the mobile unit during, at a minimum, the preceding 30 calendar days.

g. A mobile medical service licensee shall maintain all records required by Parts D and G of these regulations at a location within the Agency's jurisdiction that is:

i. A single address of use:

(1) Identified as the records retention location; and

(2) Staffed at all reasonable hours by individual(s) authorized to provide the Agency with access for purposes of inspection; or

ii When no address of use is identified on the license for records retention, the mobile unit:

(1) Identified in the license; and

(2) Whose current client's address schedule and location schedule is reported to the Agency.

Sec. G.10 - License Amendments. A licensee shall apply for and must receive a license amendment:

a. Before it receives, prepares or uses radioactive material for a type of use that is permitted under Part G, but that is not authorized on the licensee's current license issued pursuant to Part G;

b. Before it permits anyone to work as an authorized user, authorized nuclear pharmacist, or authorized medical physicist under the license, except an individual who is:

i. For an authorized user, an individual who meets the requirements in G.30 and G.46a., G.51a., G.56a., G.57a., G.58a., G.67a., G.70a., or G.88a. or;

ii. For an authorized nuclear pharmacist, an individual who meets the requirements in G.27a. and G.30;

iii. For an authorized medical physicist, an individual who meets the requirements in G.26a. and G.30;

iv. Identified as an authorized user, an authorized nuclear pharmacist, or authorized medical physicist on a Nuclear Regulatory Commission or Agreement State license or

Licensing State or other equivalent permit or license recognized by the Agency that authorizes the use of radioactive material in medical use or in the practice of nuclear pharmacy, respectively; or

v. Identified as an authorized user, an authorized nuclear pharmacist, or authorized medical physicist on a permit issued by a Nuclear Regulatory Commission or Agreement State or Licensing State specific licensee of broad scope that is authorized to permit the use of radioactive material in medical use or in the practice of nuclear pharmacy, respectively.

c. Before it changes Radiation Safety Officers, except as provided in G.18c.;

d Before it receives radioactive material in excess of the amount, or in a different physical or chemical form than is authorized on the license;

e. Before it adds to or changes the areas of use identified in the application or on the license, except as specified in G.11b.iv.;

f. Before it changes the address(es) of use identified in the application or on the license;

g. Before it changes statements, representations, and procedures which are incorporated into the license; and

h. Before it releases licensed facilities for unrestricted use.

Sec. G.11 - Notifications.

a. A licensee shall provide to the Agency a copy of the board certification, the Nuclear Regulatory Commission, Agreement State or Licensing State license, or the permit issued by a licensee of broad scope for each individual no later than 30 days after the date that the licensee permits the individual to work as an authorized user, an authorized nuclear pharmacist or an authorized medical physicist, pursuant to G.10b.

b. A licensee shall notify the Agency by letter no later than 30 days after:

i. An authorized user, an authorized nuclear pharmacist, a Radiation Safety Officer or an authorized medical physicist permanently discontinues performance of duties under the license or has a name change;

ii. The licensee's mailing address changes;

iii. The licensee's name changes, but the name change does not constitute a transfer of control of the license as described in C.31b. of these regulations; or

iv. The licensee has added to or changed the areas where radioactive material is used in accordance with G.44 and G.47.

Sec. G.15 - Exemptions Regarding Type A Specific Licenses of Broad Scope. A licensee possessing a Type A specific license of broad scope for medical use is exempt from:

a. The provisions of G.8d. regarding the need to file an amendment to the license for medical uses of radioactive material as described in G.89;

b. The provisions of G.10b. regarding the need to file an amendment before permitting anyone to work as an authorized user, an authorized nuclear pharmacist or an authorized medical physicist under the license;

c. The provisions of G.10e. regarding additions to or changes in the areas of use at the addresses specified in the license;

d. The provisions of G.11a. regarding notification to the Agency for new authorized users, new authorized nuclear pharmacists and new authorized medical physicists;

e. The provisions of G.24a. regarding suppliers for sealed sources.

Sec. G.16 - License Issuance.

a. The Agency shall issue a license for the medical use of radioactive material if:

   i. The applicant has filed [insert proper license application form ID] in accordance with the instructions in G.8;

   ii. The applicant has paid any applicable fee;

   iii. The applicant meets the requirements of Part C of these regulations; and

   iv. The Agency finds the applicant equipped and committed to observe the safety standards established by the Agency in these regulations for the protection of the public health and safety.

b. The Agency shall issue a license for mobile services if the applicant:

   i. Meets the requirements in G.16a.; and

   ii. Assures that individuals to whom radioactive drugs or radiation from implants containing radioactive material will be administered, may be released following treatment in accordance with G.40.

Sec. G.17 - Specific Exemptions. The Agency may, upon application of any interested person or upon its own initiative, grant such exemptions from the regulations in Part G as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

General Administrative Requirements

Sec. G.18 - Authority and Responsibilities for the Radiation Protection Program.

a. In addition to the radiation protection program requirements of D.101 of these regulations, a licensee's management must approve in writing:

   i. Requests for license application, renewal, or amendments before submittal to the Agency;

   ii. Any individual before allowing that individual to work as an authorized user, authorized nuclear pharmacist or authorized medical physicist; and

   iii. Radiation protection program changes that do not require a license amendment and are permitted under G.19.

b. A licensee's management shall appoint a Radiation Safety Officer, who agrees in writing to be responsible for implementing the radiation protection program. The licensee, through the Radiation Safety Officer, shall ensure that radiation safety activities are being performed in accordance with licensee-approved procedures and regulatory requirements.

c. For up to sixty days each year, a licensee may permit an authorized user or an individual qualified to be a radiation safety officer to function as a temporary Radiation Safety Officer and to perform the functions of a Radiation Safety Officer, as provided in G.18e., provided the licensee takes the actions required in G.18b.,d.,e. and h. A licensee may simultaneously appoint more than one temporary RSO, if needed, to ensure that the licensee has a temporary RSO that satisfies the requirements to be an RSO for each of the different uses of radioactive material permitted by the license.

d. A licensee shall establish in writing the authority, duties, and responsibilities of the Radiation Safety Officer.

e. A licensee shall provide the Radiation Safety Officer sufficient authority, organizational freedom, time, resources, and management prerogative, to:

   i. Identify radiation safety problems;

   ii. Initiate, recommend, or provide corrective actions;

   iii. Stop unsafe operations; and,

   iv. Verify implementation of corrective actions.

f. Licensees that are authorized for two or more different types of radioactive material use under G.52, G.59, G.71, and G.89, or two or more types of units under G.71 shall establish a

Radiation Safety Committee to oversee all uses of radioactive material permitted by the license. The Committee must include an authorized user of each type of use permitted by the license, the Radiation Safety Officer, a representative of the nursing service, and a representative of management who is neither an authorized user nor a Radiation Safety Officer, and may include other members as the licensee deems appropriate.

[g. A licensee's Radiation Safety Committee shall meet as necessary, but at a minimum shall meet at intervals not to exceed 12 [6] months. The licensee shall maintain minutes of each meeting in accordance with G.90.]

h. A licensee shall retain a record of actions taken pursuant to G.18a., G.18b. and G.18d. in accordance with G.90.

Sec. G.19 - Radiation Protection Program Changes.

a. A licensee may revise its radiation protection program without Agency approval if:

i. The revision does not require an amendment under G.10;

ii. The revision is in compliance with the regulations and the license;

iii. The revision has been reviewed and approved by the Radiation Safety Officer, licensee management and licensee's Radiation Safety Committee (if applicable); and

iv. The affected individuals are instructed on the revised program before the changes are implemented.

b. A licensee shall retain a record of each change in accordance with G.91.

Sec. G.20 - Duties of Authorized User and Authorized Medical Physicist.

a. A licensee shall assure that only authorized users for the type of radioactive material used:

i. Prescribe the radiopharmaceutical dosage and/or dose to be administered through the issuance of a written directive or reference to the diagnostic clinical procedures manual; and

ii. Direct, as specified in G.21 and G.22, or in license conditions, the administration of radioactive material for medical use to patients or human research subjects;

iii. Prepare and administer, or supervise the preparation and administration of radioactive material for medical use, in accordance with G.7b., G.7c. and G.21;

[iv. Perform the final interpretation of the results of tests, studies, or treatments]

b. A licensee shall assure that only authorized medical physicists perform, as applicable:

i. Full calibration measurements as described in G.77, G.78, and G.79;

ii. Periodic spot checks as described in G.80, G.81, and G.82; and

iii. Radiation surveys as described in G.84.

Sec. G.21 - Supervision.

a. A licensee that permits the receipt, possession, use, or transfer of radioactive material by an individual under the supervision of an authorized user or as allowed by G.7b. shall:

i. In addition to the requirements in J.12 of these regulations, instruct the supervised individual in the licensee's written radiation protection procedures, written directive procedures, regulations of Part G, and license conditions with respect to the use of radioactive material; and

ii. Require the supervised individual to follow the instructions of the supervising authorized user for medical uses of radioactive material, written radiation protection procedures, written directive procedures, regulations of Part G, and license conditions with respect to the medical use of radioactive material.

b. A licensee that permits the preparation of radioactive material for medical use by an individual under the supervision of an authorized nuclear pharmacist or physician who is an authorized user, as allowed by G.7c., shall:

i. Instruct the supervised individual in the preparation of radioactive material for medical use, as appropriate to that individual's involvement with radioactive material; and

ii. Require the supervised individual to follow the instructions of the supervising authorized user or authorized nuclear pharmacist regarding the preparation of radioactive material for medical use, the written radiation protection procedures, the regulations of Part G, and license conditions.

[c. Unless physical presence as described in other sections of Part G is required, a licensee who permits supervised activities under G.21a. and G.21b. shall require an authorized user to be immediately available (by telephone within ten minutes) to communicate with the supervised individual, and able to be physically present within one hour of notification;] and

d. A licensee that permits supervised activities under G.21a. and G.21b. is responsible for the acts and omissions of the supervised individual.

Sec. G.22 - Written Directives.

a. A written directive must be dated and signed by an authorized user prior to administration of I-131 sodium iodide greater than 1.11 megabecquerel (30 μCi), any therapeutic dosage of radioactive material or any therapeutic dose of radiation from radioactive material.

If, because of the emergent nature of the patient's condition, a delay in order to provide a written directive would jeopardize the patient's health, an oral directive will be acceptable, provided that the information contained in the oral directive is documented as soon as possible in writing in the patient's record and a written directive is prepared within 48 hours of the oral directive.

b. The written directive must contain the patient or human research subject's name and the following:

i. For an administration of a dosage of radioactive drug containing radioactive material, the radioactive drug containing radioactive material, dosage, and route of administration;

ii. For gamma stereotactic radiosurgery, the total dose, treatment site, and number of target coordinate settings per treatment for each anatomically distinct treatment site;

iii. For teletherapy, the total dose, dose per fraction, number of fractions, and treatment site;

iv. For high dose rate remote afterloading brachytherapy, the radionuclide, treatment site, dose per fraction, number of fractions, and total dose; or

v. For all other brachytherapy including LDR, MDR, and PDR:

(1) Prior to implantation: treatment site, the radionuclide, and dose; and

(2) After implantation but prior to completion of the procedure: the radioisotope, treatment site, number of sources, and total source strength and exposure time (or, the total dose).

c. A written revision to an existing written directive may be made provided that the revision is dated and signed by an authorized user prior to the administration of the dosage of radioactive drug containing radioactive material, the brachytherapy dose, the gamma stereotactic radiosurgery dose, the teletherapy dose, or the next fractional dose.

If, because of the patient's condition, a delay in order to provide a written revision to an existing written directive would jeopardize the patient's health, an oral revision to an existing written directive will be acceptable, provided that the oral revision is documented as soon as possible in the patient's record and a revised written directive is signed by the authorized user within 48 hours of the oral revision.

d. The licensee shall retain the written directive in accordance with G.92.

Sec. G.23 - Procedures for Administrations Requiring a Written Directive.

a. For any administration requiring a written directive, the licensee shall develop, implement,

and maintain written procedures to provide high confidence that:

i. The patient's or human research subject's identity is verified before each administration; and

ii. Each administration is in accordance with the written directive.

b. The procedures required by G.23a. must, at a minimum, address the following items that are applicable for the licensee's use of radioactive material:

i. Verifying the identity of the patient or human research subject;

ii. Verifying that the specific details of the administration are in accordance with the treatment plan, if applicable, and the written directive;

iii. Checking both manual and computer-generated dose calculations; and

iv. Verifying that any computer-generated dose calculations are correctly transferred into the consoles of therapeutic medical units authorized by G.71.

Sec. G.24 - Suppliers for Sealed Sources or Devices for Medical Use. For medical use, a licensee may only use:

a. Sealed sources or devices initially manufactured, labeled, packaged, and distributed in accordance with a license issued pursuant to Part C of these regulations or the equivalent requirements of the Nuclear Regulatory Commission, an Agreement State or a Licensing State; or

b. Teletherapy sources manufactured and distributed in accordance with a license issued pursuant to Part C of these regulations or the equivalent requirements of the Nuclear Regulatory Commission, an Agreement State or a Licensing State.

Sec. G.25 - Training for Radiation Safety Officer. Except as provided in G.29, the licensee shall require an individual fulfilling the responsibilities of the Radiation Safety Officer (RSO) as provided in G.18 to be an individual who:

a. Is certified by a speciality board whose certification process includes all of the requirements in G.25b. and whose certification has been recognized by the Nuclear Regulatory Commission or an Agreement State, or;*/

b. i. Has completed a structured educational program consisting of both:

(1) 200 hours of didactic training in the following areas:

(a) Radiation physics and instrumentation;

*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity;

(d) Radiation biology; and

(e) Radiation dosimetry; and

(2) One year of full-time radiation safety experience under the supervision of the individual identified as the RSO on a Nuclear Regulatory Commission or Agreement State license that authorizes similar type(s) of use(s) of radioactive material involving the following;

(a) Shipping, receiving, and performing related radiation surveys;

(b) Using and performing checks for proper operation of dose calibrators, survey meters, and instruments used to measure radionuclides;

(c) Securing and controlling radioactive material;

(d) Using administrative controls to avoid mistakes in the administration of radioactive material;

(e) Using procedures to prevent or minimize radioactive contamination and using proper decontamination procedures;

(f) Using emergency procedures to control radioactive material;

(g) Disposing of radioactive material; and

ii. Has obtained written certification, signed by a preceptor RSO, that the individual has satisfactorily completed the requirements in G.25b.i. and has achieved a level of radiation safety knowledge sufficient to independently function as an RSO for medical uses of radioactive material; or

c. Is an authorized user, authorized medical physicist, or authorized nuclear pharmacist identified on the licensee's license and has experience with the radiation safety aspects of similar types of use of radioactive material for which the individual has Radiation Safety Officer responsibilities.

Sec. G.26 - Training for Authorized Medical Physicist. The licensee shall require the authorized medical physicist to be an individual who:

a. Is certified by a speciality board whose certification process includes all of the training and experience requirements in G.26b. and whose certification has been recognized by the

Nuclear Regulatory Commission or an Agreement State*/; or

b. i. Holds a master's or doctor's degree in physics, biophysics, radiological physics, medical physics, or health physics, or an equivalent training program approved by the Agency, another Agreement State or the Nuclear Regulatory Commission and has completed one year of full-time training in therapeutic radiological physics and an additional year of full-time practical experience under the supervision of a medical physicist at a medical institution that includes the tasks listed in G.36, G.64e.,G.77, G.78, G.79, G.80, G.81, G.82 and G.84, as applicable; and

ii. Has obtained written certification, signed by a preceptor authorized medical physicist, that the individual has satisfactorily completed the requirements in G.26b.i. and has achieved a level of competency sufficient to independently function as an authorized medical physicist for each type of therapeutic medical unit for which the individual is requesting authorized medical physicist status.

Sec. G.27 - Training for an Authorized Nuclear Pharmacist. The licensee shall require the authorized nuclear pharmacist to be a pharmacist who:

a. Is certified as a nuclear pharmacist by a specialty board whose certification process includes all of the requirements in G.27b. and whose certification has been recognized by the Nuclear Regulatory Commission or an Agreement State*/; or

b. i. Has completed 700 hours in a structured educational program consisting of both:

(1) Didactic training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity;

(d) Chemistry of radioactive material for medical use; and

(e) Radiation biology; and

(2) Supervised practical experience in a nuclear pharmacy involving:

(a) Shipping, receiving, and performing related radiation surveys;

(b) Using and performing checks for proper operation of dose calibrators, survey meters, and, if appropriate, instruments used to measure alpha- or beta-emitting radionuclides;

*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

(c) Calculating, assaying, and safely preparing dosages for patients or human research subjects;

(d) Using administrative controls to avoid misadministrations in the administration of radioactive material; and

(e) Using procedures to prevent or minimize radioactive contamination and using proper decontamination procedures; and

ii. Has obtained written certification, signed by a preceptor authorized nuclear pharmacist, that the individual has satisfactorily completed the requirements in G.27b.i. and has achieved a level of competency sufficient to independently operate a nuclear pharmacy.

[Sec. G.28 - Training and Technical Requirements for Nuclear Medicine Technologists and Radiation Therapists.

a. The licensee shall require a nuclear medicine technologist using radioactive materials under the supervision of an authorized user to be an individual who:

i. Is certified in:

(1) Nuclear Medicine by the Nuclear Medicine Technology Certification Board;

(2) Nuclear Medicine by the American Registry of Radiologic Technologists with competency in Nuclear Medicine; or,

ii. Be board eligible to take the CNMT or ARRT(N) examinations; or,

iii. Has successfully completed a training program in nuclear medicine which has resulted in a certificate, associate degree, or baccalaureate degree in a nuclear medicine technology program from an accredited institution; or,

iv. Has performed as a full-time nuclear medicine technologist for a minimum of two years during the past five-year period under the supervision of an authorized user who certifies the experience in writing; or,

v. Has completed 80 hours of training and experience in basic radionuclide handling techniques applicable to the medical use of unsealed radioactive material that includes:

(1) Classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity;

(d) Chemistry of radioactive material for medical use; and

(e) Radiation biology; and

(2) Work experience, under the supervision of an authorized user involving:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Quality Control checking of instruments used to determine the activity of dosages and performing checks for proper operation of survey meters;

(c) Calculating, measuring, and safely preparing patient or human research subject dosages;

(d) Using administrative controls to prevent a misadministration involving the use of unsealed radioactive material;

(e) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures;

(f) Administering dosages to patients or human research subjects; and

(3) Has obtained written certification, signed by a preceptor authorized user that the individual has satisfactorily completed the requirements of this section and has achieved a level of radiation safety competency sufficient to independently function as a nuclear medicine technologist.

b. The licensee shall require a radiation therapist using radioactive materials under the supervision of an authorized user to be an individual who:

i. Is certified in Radiation Therapy by the American Registry of Radiologic Technologists(ARRT(T)); or

ii. Be board eligible to take the ARRT(T) examination; or,

iii. Has successfully completed a training program in radiation therapy which has resulted in a certificate, associate degree, or baccalaureate degree in a radiologic technology program that complies with the requirements of the Joint Review Committee on Education in Radiologic Technology;[1/] or,

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[1/] *"Essentials and guidelines of an Accredited Educational Program for the Radiation Therapy Technologist", Joint Review Committee on Education in Radiologic Technology, 1988.*

iv. Has performed as a full-time radiation therapist for a minimum of two years during the past five-year period under the supervision of an authorized user who certifies the experience in writing; or

v. Has completed 200 hours of training and experience in basic radionuclide handling techniques applicable to the medical use of radioactive material that includes:

(1) Classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity; and

(d) Radiation biology; and

(2) Work experience, under the supervision of an authorized user involving:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Assisting the authorized user in simulating the patient for treatment;

(c) Preparing the patient for treatment;

(d) Implementing treatment plans as prescribed by the authorized user;

(e) Providing written documentation of treatment setup and patient treatments;

(f) Quality control checks to determine that devices used to deliver the radiation doses are in compliance with institutional standards and performing checks for proper operation of survey meters;

(g) Preparing or assisting in the preparation of sources, and implantation and removal of sealed sources;

(h) Delivering doses to patients or human research subjects under the supervision of the authorized user;

(i) Maintaining running inventories of radioactive material on hand;

(j) Using administrative controls to prevent a misadministration involving the use of radioactive material; and,

(k) Properly implementing emergency procedures; and

(3) Has obtained written certification, signed by a preceptor authorized user that the individual has satisfactorily completed the requirements of this section and has achieved a level of radiation safety competency sufficient to independently function as a radiation therapist

c. Individuals working as nuclear medicine technologists or radiation therapists for a facility holding an Agency license prior to [insert effective date of these rules] need not comply with the training requirements of this section.

d. The licensee shall maintain records of the above training as specified in G.104.]

Sec. G.29 - Provisions for Experienced Radiation Safety Officer, Medical Physicist, Authorized User, and Nuclear Pharmacist.

a. An individual identified as a Radiation Safety Officer, a medical physicist, or a nuclear pharmacist on a Nuclear Regulatory Commission, an Agreement State license or on a permit issued by a Nuclear Regulatory Commission or Agreement State broad scope licensee that authorizes medical use or the practice of nuclear pharmacy, before [insert effective date of the rule] need not comply with the training requirements of G.25, G.26 and G.27, respectively.*/

b. Physicians, dentists, or podiatrists identified as authorized users for the medical, dental, or podiatric use of radioactive material on a Nuclear Regulatory Commission or Agreement State license or on a permit issued by a Nuclear Regulatory Commission or Agreement State broad scope licensee that authorizes medical use or the practice of nuclear pharmacy, issued before [insert effective date of the rule] who perform only those medical uses for which they were authorized on that date need not comply with the training requirements of G.46, G.51, G.56, G.57, G.58, G.67, G.68, G.70 and G.88.

Sec. G.30 - Recentness of Training. The training and experience specified in Part G must have been obtained within the 7 years preceding the date of application or the individual must have had related continuing education and experience since the required training and experience was completed.

General Technical Requirements

[Sec. G.31 - Quality Control of Diagnostic Equipment. Each licensee shall establish written quality control procedures for all diagnostic equipment used for radionuclide studies. As a minimum, quality control procedures and frequencies shall be those recommended by equipment manufacturers or procedures which have been approved by the Agency. The licensee shall conduct quality control procedures in accordance with written procedures.]

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*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

Sec. G.32 - Possession, Use, and Testing of Instruments to Measure the Activity of Unsealed Radioactive Materials.

a. For direct measurements performed in accordance with G.34, a licensee shall possess and use instrumentation to measure the activity of unsealed radioactive materials prior to administration to each patient or human research subject.

b. A licensee shall test the instrumentation required in G.32a. in accordance with nationally recognized standards or the manufacturer's instructions.

c. [The tests required in G.32b. shall at a minimum include tests for constancy, linearity, accuracy and geometry dependence, as appropriate to demonstrate proper operation of the instrument.

d.] A licensee shall retain a record of each instrument test required by G.32 in accordance with G.95.

Sec. G.33 - Calibration of Survey Instruments.

a. A licensee shall ensure that the survey instruments used to show compliance with Part G and Part D of these regulations have been calibrated before first use, annually, and following any repair that will affect the calibration.

b. To satisfy the requirements of G.33a., the licensee shall:

i. Calibrate all required scale readings up to 10 millisieverts (1000 mrem) per hour with a radiation source;

ii. Have each radiation survey instrument calibrated:

(1) At energies appropriate for use and at intervals not to exceed 12 months or after instrument servicing, except for battery changes;

(2) For linear scale instruments, at two points located approximately one-third and two-thirds of full-scale on each scale; for logarithmic scale instruments, at mid-range of each decade, and at two points of at least one decade; and for digital instruments, at 3 points between 0.02 and 10 millisieverts (2 and 1000 mrem) per hour; and

(3) For dose rate instruments, so that an accuracy within plus or minus 20 percent of the true radiation dose rate can be demonstrated at each point checked.

iii. Conspicuously note on the instrument the date of calibration.

c. The licensee shall not use survey instruments if the difference between the indicated exposure rate and the calculated exposure rate is greater than 20 percent.

d. [A licensee shall check each survey instrument for consistent response with a dedicated check source before each use. The licensee is not required to keep records of these checks.

e.] The licensee shall retain a record of each survey instrument calibration in accordance with G.96.

Sec. G.34 - Determination of Dosages of Radioactive Material for Medical Use.

a. A licensee shall determine and record the activity of each dosage prior to medical use. [For photon-emitting radioactive material, this determination shall be within 30 minutes prior to medical use. For all other radioactive material, this determination shall be within the period before medical use that is no greater than 10 percent of the physical half-life of the radioactive material.]

b. For a unit dosage, this determination must be made either by direct measurement or by a decay correction, based on the measurement made by a manufacturer or preparer licensed pursuant to Part C of these regulations or equivalent provisions of the Nuclear Regulatory Commission, Agreement State or Licensing State.

c. For other than unit dosages, this determination must be made by direct measurement of radioactivity or by a combination of measurements of radioactivity and mathematical calculations or combination of volumetric measurements and mathematical calculations, based on the measurement made by a manufacturer or preparer licensed pursuant to Part C of these regulations or equivalent provisions of the Nuclear Regulatory Commission, Agreement State or Licensing State.

d. Unless otherwise directed by the authorized user, a licensee shall not use a dosage if the dosage differs from the prescribed dosage by more than 20 percent.

e. A licensee shall retain a record of the dosage determination required by Part G in accordance with G.97.

Sec. G.35 - Authorization for Calibration, Transmission and Reference Sources. Any person authorized by G.7 for medical use of radioactive material may receive, possess, and use the following radioactive material for check, calibration and reference use:

a. Sealed sources manufactured and distributed by persons specifically licensed pursuant to Part C of these regulations or equivalent provisions of the Nuclear Regulatory Commission, Agreement State or Licensing State and that do not exceed 1.11 gigabecquerels (30 mCi) each;

b. Any radioactive material with a half-life of 120 days or less in individual amounts not to exceed 555 megabecquerels (15 mCi);

c. Any radioactive material with a half-life greater than 120 days in individual amounts not to exceed the smaller of:

i. 7.4 megabecquerels (200 μCi); or

ii. 1000 times the quantities in Appendix B of Part C of these regulations; and

d. Technetium-99m in amounts as needed.

Sec. G.36 - Requirements for Possession of Sealed Sources and Brachytherapy Sources.

a. A licensee in possession of any sealed source or brachytherapy source shall follow the radiation safety and handling instructions supplied by the manufacturer or equivalent instructions approved by the Agency.

b. A licensee in possession of a sealed source shall:

i. Test the source for leakage in accordance with Part D of these regulations.

ii. Test the source for leakage at intervals not to exceed 6 months or at other intervals approved by the Agency, an Agreement State, a Licensing State, or the Nuclear Regulatory Commission in the Sealed Source and Device Registry.

c. If the leak test reveals the presence of 185 becquerels (0.005 μCi) or more of removable contamination, the licensee shall:

i. Immediately withdraw the sealed source from use and store, dispose, or cause it to be repaired in accordance with the requirements of Parts C and D of these regulations;

ii. File a report with the Agency within 5 days of receiving the leak tests results in accordance with G.121.

d. A licensee in possession of a sealed source or brachytherapy source, except for gamma stereotactic radiosurgery sources, shall conduct a semi-annual physical inventory of all such sources. The licensee shall retain each inventory record in accordance with G.98.

Sec. G.37 - Labels. Each syringe and vial that contains a radioactive drug shall be labeled to identify the radioactive drug. Each syringe shield and vial shield shall also be labeled unless the label on the syringe or vial is visible when shielded.

[Sec. G.38 - Vial Shields. A licensee shall require each individual preparing or handling a vial that contains a radioactive drug to keep the vial in a vial radiation shield.]

Sec. G.39 - Surveys for Ambient Radiation Dose Rate and Contamination.

a. Except as provided in G.39b., a licensee shall survey with a radiation detection survey instrument at the end of each day of use all areas where radioactive drugs containing

radioactive material requiring a written directive were prepared for use or administered.

[b. A licensee shall survey with a radiation detection survey instrument at least once each week all areas where radioactive drugs or radioactive wastes are stored.

c. A licensee shall conduct the surveys required by G.39a. and b. so as to able to measure dose rates as low as 1 microsievert (0.1 mrem) per hour.

d. A licensee shall establish dose rate action levels for the surveys required by G.39a. and G.39b. and shall require that the individual performing the survey immediately notify the Radiation Safety Officer if a dose rate exceeds an action level.

e. A licensee shall survey for removable contamination each day of use all areas where generators and bulk radioactive drugs are prepared for use or administered and each week where radioactive materials are stored.

f. A licensee shall conduct the surveys required by G.39e. so as to be able to detect contamination on each wipe sample of 33.3 becquerels (2000 dpm).

g. A licensee shall establish removable contamination action levels for the surveys required by G.39e. and shall require that the individual performing the survey immediately notify the Radiation Safety Officer if contamination exceeds action levels.]

h. A licensee does not need to perform the surveys required by G.39a. in area(s) where patients or human research subjects are confined when they can not be released pursuant to G.40.

i. A licensee shall retain a record of each survey in accordance with G.99.

Sec. G.40 - Release of Individuals Containing Radioactive Drugs or Implants.

a. A licensee may authorize the release [from its control] of any individual who has been administered radioactive drugs or implants containing radioactive material if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed 5 millisievert (0.5 rem).

b. For patients administered radioactive material for which a written directive is required, a licensee shall provide the released individual, or the individual's parent or guardian, with oral and written instructions on actions recommended to maintain doses to other individuals as low as is reasonably achievable if the total effective dose equivalent to any other individual is likely to exceed 1 millisievert (0.1 rem). If the total effective dose equivalent to a breast-feeding infant or child could exceed 1 millisievert (0.1 rem) assuming there were no interruption of breast-feeding, the instructions shall also include:*/

    i. Guidance on the interruption or discontinuation of breast-feeding; and

*/ *This may have health and safety implications, see Rational for Part G 2002*

ii. Information on the potential consequences, if any, of failure to follow the guidance.

[b. A licensee shall provide the released individual, or the individual's parent or guardian, with oral and written instructions on actions recommended to maintain doses to other individuals as low as is reasonably achievable. If a breast-feeding infant or child could receive a radiation dose as a result of the release of the patient, the instructions shall also include:

i. Guidance on the interruption or discontinuation of breast-feeding; and

ii. Information on the potential consequences, if any, of failure to follow the guidance.]

[c. Release of the patient must be approved by an individual listed as an authorized user on the Agency license, and who is approved for the type of radioactive material use for which the patient being released has received.]

d. The licensee shall maintain a record of the basis for authorizing the release of an individual in accordance with G.100.

e. The licensee shall maintain a record of instructions provided to breast-feeding women in accordance with G.100.

[f. Notwithstanding G.40a., the licensee may be held responsible for the proper disposal of any individual's radioactive waste discovered in a solid waste stream that can be traced to the licensee.

g. The licensee shall immediately notify the Agency in accordance with G.122 if a patient departs prior to an authorized release.

h. The licensee shall notify the Agency in accordance with G.123:

i. When they are aware that a patient containing radioactive material and who has been released in accordance with G.40 dies; and,

ii. If it is possible that any individual could receive exposures in excess of 5 millisievert (500 mrem) as a result of the deceased's body.]

Sec. G.41 - Mobile Medical Service Technical Requirements. A licensee providing mobile medical service shall:

a. Transport to each client's address only syringes or vials containing prepared drugs or radioactive materials that are intended for reconstitution of radioactive drug kits;

b. Bring into each client's address all radioactive material to be used and, before leaving, remove all unused radioactive material and associated radioactive waste;

c. Secure or keep under constant surveillance and immediate control all radioactive material when in transit or at a client's address;

d. Check instruments used to measure the activity of unsealed radioactive material for proper function before medical use at each client's address or on each day of use, whichever is more frequent. At a minimum, the check for proper function shall include a constancy check;

e. Check survey instruments for consistent response with a dedicated check source before use at each client's address;

f. Prior to leaving a client's address, perform area surveys and survey for removable contamination in all areas of use, to ensure compliance with Part D of these regulations;

[g. Use radioactive gases only in areas of use and under conditions which have been evaluated and approved by the Agency for compliance with airborne release standards;] and,

h. Retain a record of each survey required by G.41f. in accordance with G.101.

[Sec. G.42 - Storage and Control of Volatiles and Gases.

a. A licensee shall store volatile radioactive materials and radioactive gases in a radiation shield and container.

b. A licensee shall store and use a multi-dose container in a properly functioning fume hood.

c. A licensee who administers radioactive aerosols or gases shall do so with a system that will keep airborne concentrations within the limits prescribed in Part D of these regulations.

d. The system shall either be directly vented to the atmosphere through an air exhaust or provide for collection and decay or disposal of the aerosol or gas in a shielded container.

e. A licensee shall check the operation of collection systems monthly. Records of these checks shall be maintained for 3 years.]

Sec. G.43 - Decay-in-Storage.

a. A licensee may hold radioactive material with a physical half-life of less than 120 days for decay-in-storage before disposal without regard to its radioactivity if the licensee:

   i. Monitors radioactive material at the container surface before disposal and determines that its radioactivity cannot be distinguished from the background radiation level with an appropriate radiation detection survey instrument set on its most sensitive scale and with no interposed shielding;

   ii. Removes or obliterates all radiation labels, except for material that will be handled as biomedical waste after release; and

   iii. Separates and monitors each generator column individually with all radiation shielding removed to ensure that its contents have decayed to background radiation level before disposal.

b. For radioactive material disposed in accordance with G.43a. of this section, the licensee shall retain a record of each disposal in accordance with G.102.

Specific Requirements for the Use of Radioactive Material for Uptake, Dilution, or Excretion Studies

Sec. G.44 - Use of Unsealed Radioactive Material for Uptake, Dilution, or Excretion Studies for which a Written Directive is Not Required. A licensee may use any unsealed radioactive material, in quantities that do not require a written directive, for a diagnostic use involving measurements of uptake, dilution, or excretion that is:

a. Obtained from a manufacturer or preparer licensed pursuant to Part C of these regulations or equivalent regulations of another Agreement State, a Licensing State, or the Nuclear Regulatory Commission; or

b. Prepared by an authorized nuclear pharmacist, a physician who is an authorized user and who meets the requirements specified in G.46, G.51, or an individual under the supervision of either as specified in G.21; or

c. Obtained from and prepared by an Agency, Nuclear Regulatory Commission, Agreement State or Licensing State licensee for use in research in accordance with a Radioactive Drug Research Committee-approved protocol or an Investigational New Drug (IND) protocol accepted by FDA; or

d. Prepared by the licensee in accordance with a Radioactive Drug Research Committee-approved application or an Investigational New Drug (IND) protocol accepted by FDA for use in research.

[Sec. G.45 - Possession of Survey Instrument. A licensee authorized to use radioactive material for uptake, dilution, and excretion studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1 microsievert (0.1 mrem) per hour to 500 microsieverts (50 mrems) per hour. The instrument shall be operable and calibrated in accordance with G.33.]

Sec. G.46 - Training for Uptake, Dilution, and Excretion Studies. Except as provided in G.29, the licensee shall require an authorized user of an unsealed radioactive material for the uses authorized under G.44 to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.46c. and whose certification has been recognized by the Nuclear Regulatory Commission, or an Agreement State; or

b. Is an authorized user under G.51 or G.56, or equivalent Agreement State or Nuclear Regulatory Commission requirements; or

c. i. Has completed 60 hours of training and experience in basic radionuclide handling techniques applicable to the medical use of unsealed radioactive material for uptake, dilution, and excretion studies that includes:

(1) Classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity;

(d) Chemistry of radioactive material for medical use; and

(e) Radiation biology; and

(2) Work experience, under the supervision of an authorized user who meets the requirements in G.46, G.51 or G.56 or equivalent Agreement State, or Nuclear Regulatory Commission requirements, involving:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Calibrating instruments used to determine the activity of dosages and performing checks for proper operation of survey meters;

(c) Calculating, measuring, and safely preparing patient or human research subject dosages;

(d) Using administrative controls to prevent a misadministration involving the use of unsealed radioactive material;

(e) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures; and

(f) Administering dosages to patients or human research subjects; and

ii. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.46, G.51 or G.56 or equivalent Agreement State, or Nuclear Regulatory Commission requirements, that the individual has satisfactorily completed the requirements in G.46c.i. and has achieved a level of competency sufficient to independently function as an authorized user for the medical uses authorized under G.44.*/

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*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

Specific Requirements for the Use of Unsealed Radioactive Material - Written Directive Not Required

Sec. G.47 - Use of Unsealed Radioactive Material for Imaging and Localization Studies for which a Written Directive is Not Required. A licensee may use, for imaging and localization studies, any radioactive material prepared for medical use, in quantities that do not require a written directive as described in G.22 that is:

a. Obtained from a manufacturer or preparer licensed pursuant to Part C of these regulations or equivalent regulations of another Agreement State, a Licensing State, or the Nuclear Regulatory Commission; or

b. Prepared by an authorized nuclear pharmacist, a physician who is an authorized user and who meets the requirements specified in G.51, or an individual under the supervision of either as specified in G.21; or

c. Obtained from and prepared by an Agency, Nuclear Regulatory Commission, Agreement State or Licensing State licensee for use in research in accordance with a Radioactive Drug Research Committee-approved protocol or an Investigational New Drug (IND) protocol accepted by FDA; or

d. Prepared by the licensee in accordance with a Radioactive Drug Research Committee-approved application or an Investigational New Drug (IND) protocol accepted by FDA.

e. Provided the conditions of G.42 are met, a licensee shall use radioactive aerosols or gases only if specific application is made to and approved by the Agency.

Sec. G.48 - Radionuclide Contaminants.

a. A licensee shall not administer to humans a radioactive drug containing:

   i. More than 0.15 kilobecquerel of molybdenum-99 per megabecquerel of technetium-99m (0.15 μCi of Mo-99 per mCi of Tc-99m);

   ii. More than 0.02 kilobecquerel of strontium-82 per megabecquerel of rubidium-82 chloride injection (0.02 μCi of Sr-82 per mCi of Rb-82 chloride);

   iii. More than 0.2 kilobecquerel of strontium-85 per megabecquerel of rubidium-82 chloride injection (0.2 μCi of Sr-85 per mCi of Rb-82).

b. To demonstrate compliance with G.48a., the licensee preparing radioactive drugs from radionuclide generators shall:

i. Measure the concentration of radionuclide contaminant in the first eluate after receipt of a molybdenum-99/technetium-99m generator;

ii. Measure the concentration of radionuclide contaminant in each eluate or extract, as appropriate for other generator systems.

c. A licensee who must measure radionuclide contaminant concentration shall retain a record of each measurement in accordance with G.103.

d. A licensee shall report immediately to the Agency each occurrence of radionuclide contaminant concentration exceeding the limits specified in G.48a.

[Sec. G.49 - Reserved.]

[Sec. G.50 - Possession of Survey Instruments. A licensee authorized to use radioactive material for imaging and localization studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1 microsievert (0.1 mrem) per hour to 500 microsieverts (50 mrems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 10 microsieverts (1 mrem) per hour to 10 millisieverts (1000 mrems) per hour. The instruments shall be operable and calibrated in accordance with G.33.]

Sec. G.51 - Training for Imaging and Localization Studies. Except as provided in G.29, the licensee shall require an authorized user of unsealed radioactive material for the uses authorized under G.47 to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.51c. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission;*/ or

b. Is an authorized user under G.56, or equivalent Agreement State, or Nuclear Regulatory Commission requirements; or

c. i. Has completed 700 hours of training and experience in basic radionuclide handling techniques applicable to the medical use of unsealed radioactive material for imaging and localization studies that includes, at a minimum:

(1) Classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity;

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*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

(d) Chemistry of radioactive material for medical use;

(e) Radiation biology; and

(2) Work experience, under the supervision of an authorized user, who meets the requirements in G.51 or G.56, or equivalent Agreement State, or Nuclear Regulatory Commission requirements, involving:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Calibrating instruments used to determine the activity of dosages and performing checks for proper operation of survey meters;

(c) Calculating, measuring, and safely preparing patient or human research subject dosages;

(d) Using administrative controls to prevent a misadministration involving the use of unsealed radioactive material;

(e) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures;

(f) Administering radiopharmaceutical dosages to patients or human research subjects; and

(g) Eluting generator systems appropriate for preparation of radioactive drugs for imaging and localization studies, measuring and testing the eluate for radiochemical purity, and processing the eluate with reagent kits to prepare labeled radioactive drugs; and

ii. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.51 or G.56, or equivalent Agreement State, or Nuclear Regulatory Commission requirements, that the individual has satisfactorily completed the requirements in G.51c.i. and has achieved a level of competency sufficient to independently function as an authorized user for the medical uses authorized under G.47.

Specific Requirements for the Use of Unsealed Radioactive Material - Written Directive Required

Sec. G.52 - Use of Unsealed Radioactive Material for which a Written Directive is Required. A licensee may use any unsealed radioactive material for diagnostic or therapeutic medical use for which a written directive is required that has been:

a. Obtained from a manufacturer or preparer licensed in accordance with Part C of these

regulations; or

b. Prepared by an authorized nuclear pharmacist, a physician who is an authorized user and who meets the requirements specified in G.51 or G.56, or an individual under the supervision of either as specified in G.29; or

c. Obtained from and prepared by an Agency, Nuclear Regulatory Commission, Agreement State, or Licensing State licensee in accordance with a Radioactive Drug Research Committee-approved protocol or an Investigational New Drug (IND) protocol accepted by the FDA for use in research; or

d. Prepared by the licensee in accordance with a Radioactive Drug Research Committee-approved application or an IND protocol accepted by FDA for use in research.

Sec. G.53 - Safety Instruction. In addition to the requirements of J.12 of these regulations:

a. A licensee shall provide radiation safety instruction to personnel caring for patients or human research subjects that have received therapy with a radioactive drug, and cannot be released in accordance with G.40. The training must be provided initially and at least annually. The instruction must be appropriate to the personnel's assigned duties and include the following:

   i. Patient or human research subject control;

   ii. Visitor control to include the following:

      (1) Routine visitation to hospitalized individuals in accordance with Part D of these regulations;

      (2) Contamination control;

      (3) Waste control; and

      (4) Notification of the RSO, or his or her designee, and the authorized user if the patient or the human research subject dies or has a medical emergency.

b. A licensee shall retain a record of individuals receiving instruction in accordance with G.105.

Sec. G.54 - Safety Precautions.

a. For each patient or human research subject receiving radiopharmaceutical therapy and hospitalized for compliance with G.40, a licensee shall:

   i. Quarter the patient or the human research subject either in:

      (1) A private room with a private sanitary facility; or

      (2) A room, with a private sanitary facility, with another individual who also has

received similar radiopharmaceutical therapy and who cannot be released in accordance with G.40; and,

ii. Visibly post the patient's or the human research subject's room with a "Radioactive Materials" sign and note on the door or in the patient's or human research subject's chart where and how long visitors may stay in the patient's or the human research subject's room; and

iii. Either monitor material and items removed from the patient's or the human research subject's room to determine that their radioactivity cannot be distinguished from the natural background radiation level with a radiation detection survey instrument set on its most sensitive scale and with no interposed shielding, or handle such material and items as radioactive waste.

b. The Radiation Safety Officer, or his or her designee, and the authorized user shall be notified immediately if the hospitalized patient dies or has a medical emergency. The licensee shall also notify the Agency in accordance with G.123 if it is possible that any individual could receive exposures in excess of Part D.301 of these regulations as a result of the deceased's body.

[Sec. G.55 - Possession of Survey Instruments. A licensee authorized to use radioactive material for which a written directive is required shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1 microsievert (0.1 mrem) per hour to 500 microsieverts (50 mrems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 10 microsieverts (1 mrem) per hour to 10 millisieverts (1000 mrems) per hour. The instruments shall be operable and calibrated in accordance with G.33.]

Sec. G.56 - Training for Use of Unsealed Radioactive Material for which a Written Directive is Required. Except as provided in G.29, the licensee shall require an authorized user of radioactive material for the uses authorized under G.52 to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements of G.56b. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission;*/ or

b. i. Has completed 700 hours of training and experience in basic radionuclide handling techniques applicable to the medical use of unsealed radioactive material requiring a written directive, that includes:

(1) Classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

(c) Mathematics pertaining to the use and measurement of radioactivity;

(d) Chemistry of radioactive material for medical use; and

(e) Radiation biology; and

(2) Work experience, under the supervision of an authorized user who meets the requirements in G.56 or equivalent Agreement State, or Nuclear Regulatory Commission requirements. A supervising authorized user, who meets the requirements of G.56b. must have experience in administering dosages in the same dosage category or categories listed in G.56b.ii. as the individual requesting authorized user status. The work experience must involve:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Calibrating instruments used to determine the activity of dosages, and performing checks for proper operation of survey meters;

(c) Calculating, measuring, and safely preparing patient or human research subject dosages;

(d) Using administrative controls to prevent a misadministration involving the use of unsealed radioactive material;

(e) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures;

(f) Administering dosages to patients or human research subjects; and

(g) Eluting generator systems, measuring and testing the eluate for radiochemical purity, and processing the eluate with reagent kits to prepare labeled radioactive drugs containing radioactive material; and

ii. Administering dosages of radioactive drugs to patients or human research subjects involving a minimum of 3 cases in each of the following categories for which the individual is requesting authorized user status. This experience may be obtained concurrently with the supervised work experience required by G.56b.i.(2):

(1) Oral administration of less than or equal to 1.22 gigabecquerels (33 millicuries) of sodium iodide I-131;

(2) Oral administration of greater than 1.22 gigabecquerels (33 millicuries) of sodium iodide I-131;[2/]

[2/] *Experience with at least 3 cases in category (2) also satisfies the requirement in category (1).*

(3) Parenteral administration of any beta emitter or a photon-emitting radionuclide with a photon energy less than 150 keV; and/or

(4) Parenteral administration of any other radionuclide; and

iii. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.56 or equivalent Agreement State, or Nuclear Regulatory Commission requirements, that the individual has satisfactorily completed the requirements G.56b.i. and G.56b.ii. and has achieved a level of competency sufficient to independently function as an authorized user for the medical uses authorized under G.56. The preceptor authorized user who meets the requirements of G.56b. must have experience in administering dosages in the same dosage category or categories listed in G.56b.ii. as the individual requesting authorized user status.

Sec. G.57 - Training for the Oral Administration of Sodium Iodide I-131 in Quantities Less than or Equal to 1.22 Gigabecquerels (33 millicuries) for which a Written Directive is Required.[*/] Except as provided in G.29, the licensee shall require an authorized user for the oral administration of sodium iodide I-131 in quantities less than or equal to 1.22 gigabecquerels (33 millicuries), for which a written directive is required, to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.57c. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission;[**/] or

b. Is an authorized user under G.56a., G.56b., for uses listed in G.56b.ii.(1) or (2), G.58 or equivalent Agreement State or Nuclear Regulatory Commission requirements; or

c. i. Has successfully completed 80 hours classroom and laboratory training, applicable to the medical use of sodium iodide I-131 for procedures requiring a written directive; the training must include:

(1) Radiation physics and instrumentation;

(2) Radiation protection;

(3) Mathematics pertaining to the use and measurement of radioactivity;

(4) Chemistry of radioactive material for medical use; and

(5) Radiation biology; and

ii. Has work experience under the supervision of an authorized user who meets the requirements in G.56a., G.56b., G.57 or G.58, or equivalent Agreement State, or Nuclear Regulatory Commission requirements. A supervising authorized user who

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[*/] *This rule has possible health and safety implications, please see Rationale for Part G 2002 for additional information.*

[**/] *Licensing States not included because of compatibility B. States may want to recognize the Licensing States Certification for NARM.*

meets the requirements of G.56b. must have experience in administering dosages as specified in G.56b.ii.(1) or G.56b.ii.(2); the work experience must involve:

(1) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(2) Calibrating instruments used to determine the activity of dosages and performing checks for proper operation for survey meters;

(3) Calculating, measuring, and safely preparing patient or human research subject dosages;

(4) Using administrative controls to prevent a misadministration involving the use of radioactive material;

(5) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures;

(6) Administering dosages to patients or human research subjects that includes at least 3 cases involving the oral administration of less than or equal to 1.22 gigabecquerels (33 millicuries) of sodium iodide I-131; and

iii. Has obtained written certification that the individual has satisfactorily completed the requirements in G.57c.i. and G.57c.ii., and has achieved a level of competency sufficient to independently function as an authorized user for medical uses of unsealed radioactive material using sodium iodide I-131. The written certification must be signed by a preceptor authorized user who meets the requirements of G.56a., G.56b, G.57 or G.58, or equivalent Agreement State or Nuclear Regulatory Commission requirements. The preceptor authorized user who meets the requirements of G.56b. must have experience in administering dosages as specified in G.56b.ii.(1) and/or (2).

Sec. G.58 - Training for the Oral Administration of Sodium Iodide I-131 in Quantities Greater than 1.22 Gigabecquerels (33 millicuries) for which a Written Directive is Required.[*/] Except as provided in G.29, the licensee shall require an authorized user for the oral administration of sodium iodide I-131 in quantities greater than 1.22 gigabecquerels (33 millicuries), to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.57c. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission; or

b. Is an authorized user under G.56a., G.56b. for uses listed in G.56b.ii.(2), or equivalent Agreement State, Licensing State or Nuclear Regulatory Commission requirements; or

c. i. Has successfully completed 80 hours classroom and laboratory training, applicable to

[*/] This rule has possible health and safety implications, please see Rationale for Part G 2002 for more information.

the medical use of sodium iodide I-131 for procedures requiring a written directive; the training must include:

(1) Radiation physics and instrumentation;

(2) Radiation protection;

(3) Mathematics pertaining to the use and measurement of radioactivity;

(4) Chemistry of radioactive material for medical use; and

(5) Radiation biology; and

ii. Has work experience, under the supervision of an authorized user who meets the requirements in G.56a., G.56b., G.58, or equivalent Agreement State, or Nuclear Regulatory Commission requirements. A supervising authorized user, who meets the requirements of G.56b., must have experience in administering dosages as specified in G.56b.ii.(2). The work experience must involve:

(1) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(2) Calibrating instruments used to determine the activity of dosages and performing checks for proper operation for survey meters;

(3) Calculating, measuring, and safely preparing patient or human research subject dosages;

(4) Using administrative controls to prevent a misadministration involving the use of radioactive material;

(5) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures;

(6) Administering dosages to patients or human research subjects that includes at least 3 cases involving the oral administration of greater than 1.22 gigabecquerels (33 millicuries) of sodium iodide I-131; and

iii. Has obtained written certification that the individual has satisfactorily completed the requirements in G.58c.i. and G.58c.ii. and has achieved a level of competency sufficient to independently function as an authorized user for medical uses of unsealed radioactive material using sodium iodide I-131 in activities greater than 1.22 gigabecquerels (33 millicuries). The written certification must be signed by a preceptor authorized user, who meets the requirements of G.56b., G.58, or equivalent Agreement State or Nuclear Regulatory Commission requirements. A preceptor authorized user who meets the requirements of G.56b., must have experience in administering dosages as specified in G.56b.ii.(2).

Manual Brachytherapy

Sec. G.59 - Use of Sealed Sources for Manual Brachytherapy. A licensee shall use only brachytherapy sources for therapeutic medical uses:

a. As approved in the Sealed Source and Device Registry; or

b. In research in accordance with an effective Investigational Device Exemption (IDE) application accepted by the FDA provided the requirements of G.24a. are met.

Sec. G.60 - Surveys After Source Implant and Removal.

a. Immediately after implanting sources in a patient or a human research subject, the licensee shall perform a survey to locate and account for all sources that have not been implanted.

b. Immediately after removing the last temporary implant source from a patient or a human research subject, the licensee shall make a survey of the patient or the human research subject with a radiation detection survey instrument to confirm that all sources have been removed.

c. A licensee shall retain a record of the surveys in accordance with G.106.

Sec. G. 61 - Brachytherapy Sources Inventory.

a. A licensee shall maintain accountability at all times for all brachytherapy sources in storage or use.

b. Promptly after removing sources from a patient or a human research subject, a licensee shall return brachytherapy sources to a secure storage area.

c. A licensee shall maintain a record of the brachytherapy source accountability in accordance with G.107.

Sec. G.62 - Safety Instruction. In addition to the requirements of J.12 of these regulations:

a. The licensee shall provide radiation safety instruction, initially and at least annually, to personnel caring for patients or human research subjects that are undergoing implant therapy and cannot be released in accordance with G.40. Instruction must be commensurate with the duties of the personnel and shall include the following:

   i. Size and appearance of the brachytherapy sources;

   ii. Safe handling and shielding instructions;

   iii. Patient or human research subject control;

iv. Visitor control, including both:

(1) Routine visitation of hospitalized individuals in accordance with D.301a.i. of these regulations; and

(2) Visitation authorized in accordance with D.301c. of these regulations; and

v. Notification of the Radiation Safety Officer, or his or her designee, and an authorized user if the patient or the human research subject dies or has a medical emergency. The licensee shall also notify the Agency in accordance with G.123 if it is possible that any individual could receive exposures in excess of 5 millisievert (500 mrem) as a result of the deceased's body.

b. A licensee shall retain a record of individuals receiving instruction in accordance with G.105.

Sec. G.63 - Safety Precautions for Patients or Human Research Subjects Receiving Brachytherapy.

a. For each patient or human research subject that is receiving brachytherapy and cannot be released in accordance with G.40, a licensee shall:

i. Not place the patient or human research subject in the same room as an individual who is not receiving brachytherapy;

ii. Visibly post the patient's or human research subject's room with a "Radioactive Materials" sign and note on the door or in the patient's or human research subject's chart where and how long visitors may stay in the patient's or human research subject's room.

b. A licensee shall have emergency response equipment available near each treatment room to respond to a source that inadvertently becomes:

i. Dislodged from the patient; or

ii. Lodged within the patient following removal of the source applicators.

c. The Radiation Safety Officer, or his or her designee, and the authorized user shall be notified immediately if the hospitalized patient or human research subject dies or has a medical emergency.

Sec. G.64 - Calibration Measurements of Brachytherapy Sealed Sources.

a. Prior to the first medical use of a brachytherapy sealed source on or after [insert effective date of the rule], a licensee shall perform the following:

i. Determine the source output or activity using a dosimetry system that meets the requirements of G.76a.;

ii. Determine source positioning accuracy within applicators; and

iii. Use published protocols accepted by nationally recognized bodies to meet the requirements of G.64a.i. and G.64a.ii.

b. A licensee may use measurements provided by the source manufacturer [or by a calibration laboratory accredited by the American Association of Physicists in Medicine] that are made in accordance with G.64a.

c. A licensee shall mathematically correct the outputs or activities determined in G.64a. of this section for physical decay at intervals consistent with 1.0 percent physical decay.

d. An authorized medical physicist shall perform or review the calculation measurements made pursuant to G.64a., G.64b., or G.64c.

e. Only an authorized medical physicist shall calculate the activity of each strontium-90 source that is used to determine the treatment times for ophthalmic treatments. The decay must be based on the activity determined in accordance with paragraphs G.64a., G.64b., and G.64c.

f. A licensee shall retain a record of each calibration in accordance with G.108.

g. A licensee shall retain a record of decay calculations required by G.64e. in accordance with G.109.

Sec. G.65 - Therapy-related Computer Systems. The licensee shall perform acceptance testing on the treatment planning system in accordance with published protocols accepted by nationally recognized bodies. At a minimum, the acceptance testing must include, as applicable, verification of:

a. The source-specific input parameters required by the dose calculation algorithm;

b. The accuracy of dose, dwell time, and treatment time calculations at representative points;

c. The accuracy of isodose plots and graphic displays; and

d The accuracy of the software used to determine radioactive source positions from radiographic images.

[Sec. G.66 - Possession of Survey Instruments. A licensee authorized to use manual brachytherapy sources shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1 microsievert (0.1 mrem) per hour to 500 microsieverts (50 mrems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 10 microsieverts (1 mrem) per hour to 10 millisieverts (1000 mrems) per hour. The instruments shall be operable and calibrated in accordance with G.33.]

Sec. G.67 - Training for Use of Manual Brachytherapy Sources. Except as provided in G.29, the licensee shall require an authorized user of a manual brachytherapy source for the uses authorized

under G.59 to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.67b. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission;*/ or

b. i. Has completed a structured educational program in basic radionuclide handling techniques applicable to the use of manual brachytherapy sources that includes:

(1) 200 hours of classroom and laboratory training in the following areas:

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity; and

(d) Radiation biology; and

(2) 500 hours of work experience, under the supervision of an authorized user who meets the requirements in G.67 or equivalent Agreement State, or Nuclear Regulatory Commission requirements at a medical institution, involving:

(a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;

(b) Checking survey meters for proper operation;

(c) Preparing, implanting, and removing brachytherapy sources;

(d) Maintaining running inventories of material on hand;

(e) Using administrative controls to prevent a misadministration involving the use of radioactive material;

(f) Using emergency procedures to control radioactive material; and

ii. Three years of supervised clinical experience in radiation oncology, under an authorized user who meets the requirements in G.67 or equivalent Agreement State or Nuclear Regulatory Commission requirements, as part of a formal training program approved by the Residency Review Committee for Radiation Oncology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association. This experience may be obtained concurrently with the supervised work experience required by

*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

G.67b.i.(2); and

iii. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.67 or equivalent Agreement State or Nuclear Regulatory Commission requirements, that the individual has satisfactorily completed the requirements in G.67b.i. and G.67b.ii. and has achieved a level of competency sufficient to independently function as an authorized user of manual brachytherapy sources for the medical uses authorized under G.59.

Sec. G.68 - Training for ophthalmic use of strontium-90. Except as provided in G.29, the licensee shall require an authorized user of a strontium-90 source for ophthalmic uses authorized under G.59 to be a physician who:

a. Is an authorized user under G.67 or equivalent Agreement State or Nuclear Regulatory Commission requirements;*/ or,

b. i. Has completed 24 hours of classroom and laboratory training applicable to the medical use of strontium-90 for ophthalmic radiotherapy. The training must include:

(1) Radiation physics and instrumentation;

(2) Radiation protection;

(3) Mathematics pertaining to the use and measurement of radioactivity; and,

(4) Radiation biology; and,

ii. Supervised clinical training in ophthalmic radiotherapy under the supervision of an authorized user who meets the requirements of G.67 or G.68, and that includes the use of strontium-90 for the ophthalmic treatment of five individuals that includes:

(1) Examination of each individual to be treated;

(2) Calculation of the dose to be administered;

(3) Administration of the dose; and,

(4) Follow-up and review of each individual's case history; and,

iii. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.67 or G.68 or equivalent Agreement State or Nuclear Regulatory Commission requirements, that the individual has satisfactorily completed the requirements in paragraphs i. and ii. of this section and has achieved a level of competency sufficient to independently function as an authorized user of strontium-90 for ophthalmic use.

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*/ *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

Sealed Sources For Diagnosis

Sec. G.69 - Use of Sealed Sources for Diagnosis. A licensee shall use only sealed sources for diagnostic medical uses:

a. Approved in the Sealed Source and Device Registry; and,

b. Handled in accordance with the manufacturer's radiation safety instructions.

Sec. G.70 - Training for Use of Sealed Sources for Diagnosis. Except as provided in G.29, the licensee shall require the authorized user of a diagnostic sealed source for use in a device authorized under G.69 to be a physician, dentist, or podiatrist who:

a. Is certified by a speciality board whose certification process includes all of the requirements in G.70b. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission; [*]/or

b. Has had 8 hours of classroom and laboratory training in basic radionuclide handling techniques specifically applicable to the use of the device that includes:

   i. Radiation physics and instrumentation;

   ii. Radiation protection;

   iii. Mathematics pertaining to the use and measurement of radioactivity;

   iv. Radiation biology; and

   v. Training in the use of the device for the uses requested.

Photon Emitting Remote Afterloader Units, Teletherapy Units, and Gamma Stereotactic Radiosurgery Units

Sec. G.71 - Use of Sealed Sources in a Remote Afterloader Unit, Teletherapy Unit, or Gamma Stereotactic Radiosurgery Unit. A licensee shall use sealed sources in photon emitting remote afterloader units, teletherapy units, or gamma stereotactic radiosurgery units for therapeutic medical uses:

a. As approved in the Sealed Source and Device Registry; or

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[*]/ *Licensing State not included because of compatibility B. State may want to recognize the Licensing State certification for NARM.*

b. In research in accordance with an effective Investigational Device Exemption (IDE) application accepted by the FDA provided the requirements of G.24a. are met.

Sec. G.72 - Surveys of Patients and Human Research Subjects Treated with a Remote Afterloader Unit.

a. Before releasing a patient or a human research subject from licensee control, a licensee shall make a survey of the patient or the human research subject and the remote afterloader unit with a portable radiation detection survey instrument to confirm that the source(s) has been removed from the patient or human research subject and returned to the safe, shielded position.

b. A licensee shall retain a record of the surveys in accordance with G.106.

Sec. G.73 - Installation, Maintenance, Adjustment, and Repair.

a. Only a person specifically licensed by the Agency, the Nuclear Regulatory Commission or an Agreement State shall install, maintain, adjust, or repair a remote afterloader unit, teletherapy unit, or gamma stereotactic radiosurgery unit that involves work on the source(s) shielding, the source(s) driving unit, or other electronic or mechanical component that could expose the source(s), reduce the shielding around the source(s), or compromise the radiation safety of the unit or the source(s).

b. Except for low dose-rate remote afterloader units, only a person specifically licensed by the Agency, an Agreement State, Licensing State or the Nuclear Regulatory Commission shall install, replace, relocate, or remove a sealed source or source contained in other remote afterloader units, teletherapy units, or gamma stereotactic radiosurgery units.

c. For a low dose-rate remote afterloader unit, only a person specifically licensed by the Agency, an Agreement State, Licensing State or the Nuclear Regulatory Commission, or an authorized medical physicist shall install, replace, relocate, or remove a sealed source(s) contained in the unit.

d. A licensee shall retain a record of the installation, maintenance, adjustment and repair done on remote afterloader units, teletherapy units, and gamma stereotactic radiosurgery units in accordance with G.110.

Sec. G.74 - Safety Procedures and Instructions for Remote Afterloader Units, Teletherapy Units, and Gamma Stereotactic Radiosurgery Units.

a. A licensee shall:

   i. Secure the unit, the console, the console keys, and the treatment room when not in use or unattended;

   ii. Permit only individuals approved by the authorized user, Radiation Safety Officer, or authorized medical physicist to be present in the treatment room during treatment

with the source(s);

iii. Prevent dual operation of more than one radiation producing device in a treatment room, if applicable; and

iv. Develop, implement, and maintain written procedures for responding to an abnormal situation when the operator is unable to place the source(s) in the shielded position, or remove the patient or human research subject from the radiation field with controls from outside the treatment room. This procedure must include:

(1) Instructions for responding to equipment failures and the names of the individuals responsible for implementing corrective actions;

(2) The process for restricting access to and posting of the treatment area to minimize the risk of inadvertent exposure; and

(3) The names and telephone numbers of the authorized users, the authorized medical physicist, and the Radiation Safety Officer to be contacted if the unit or console operates abnormally.

b. A copy of the procedures required by G.74a.iv. must be physically located at the unit console.

c. A licensee shall post instructions at the unit console to inform the operator of:

i. The location of the procedures required by G.74a.iv.; and

ii. The names and telephone numbers of the authorized users, the authorized medical physicist, and the Radiation Safety Officer to be contacted if the unit or console operates abnormally.

d. A licensee shall provide instruction, initially and at least annually, to all individuals who operate the unit, as appropriate to the individual's assigned duties, in:

i. The procedures identified in G.74a.iv.; and

ii. The operating procedures for the unit.

e. A licensee shall ensure that operators, authorized medical physicists, and authorized users participate in drills of the emergency procedures, initially and at least annually.

f. A licensee shall retain a record of individuals receiving instruction required by G.74d., in accordance with G.105.

Sec. G.75 - Safety Precautions for Remote Afterloader Units, Teletherapy Units, and Gamma Stereotactic Radiosurgery Units.

a. A licensee shall control access to the treatment room by a door at each entrance.

b. A licensee shall equip each entrance to the treatment room with an electrical interlock system that will:

   i. Prevent the operator from initiating the treatment cycle unless each treatment room entrance door is closed;

   ii. Cause the source(s) to be shielded promptly when an entrance door is opened; and

   iii. Prevent the source(s) from being exposed following an interlock interruption until all treatment room entrance doors are closed and the source(s) on-off control is reset at the console.

c. A licensee shall require any individual entering the treatment room to assure, through the use of appropriate radiation monitors, that radiation levels have returned to ambient levels.

d. Except for low-dose remote afterloader units, a licensee shall construct or equip each treatment room with viewing and intercom systems to permit continuous observation of the patient or the human research subject from the treatment console during irradiation.

e. For licensed activities where sources are placed within the patient's or human research subject's body, a licensee shall only conduct treatments which allow for expeditious removal of a decoupled or jammed source.

f. In addition to the requirements specified in G.75a. through G.75e., a licensee shall:

   i. For [low dose-rate,] medium dose-rate, and pulsed dose-rate remote afterloader units, require:

      (1) An authorized medical physicist and either an authorized user or a physician, under the supervision of an authorized user, who has been trained in the operation and emergency response for the unit to be physically present during the initiation of all patient treatments involving the unit; and

      (2) An authorized medical physicist and either an authorized user or an individual, under the supervision of an authorized user, who has been trained to remove the source applicator(s) in the event of an emergency involving the unit, to be immediately available during continuation of all patient treatments involving the unit.

   ii. For high dose-rate remote afterloader units, require:

      (1) An authorized user and an authorized medical physicist to be physically present during the initiation of all patient treatments involving the unit; and

      (2) An authorized medical physicist and either an authorized user or a physician,

under the supervision of an authorized user, who has been trained in the operation and emergency response for the unit, to be physically present during continuation of all patient treatments involving the unit.

iii. For gamma stereotactic radiosurgery units, require an authorized user and an authorized medical physicist to be physically present throughout all patient treatments involving the unit.

iv. Notify the Radiation Safety Officer, or his or her designee, and an authorized user as soon as possible, if the patient or human research subject has a medical emergency and, immediately, if the patient dies.

g. A licensee shall have emergency response equipment available near each treatment room, to respond to a source that inadvertently:

i. Remains in the unshielded position; or

ii. Lodges within the patient following completion of the treatment.

Sec. G.76 - Dosimetry Equipment.

a. Except for low dose-rate remote afterloader sources where the source output or activity is determined by the manufacturer, a licensee shall have a calibrated dosimetry system available for use. To satisfy this requirement, one of the following two conditions must be met.

i. The system must have been calibrated using a system or source traceable to the National Institute of Standards and Technology (NIST) and published protocols accepted by nationally recognized bodies; or by a calibration laboratory accredited by the American Association of Physicists in Medicine (AAPM). The calibration must have been performed within the previous 2 years and after any servicing that may have affected system calibration; or

ii. The system must have been calibrated within the previous 4 years; 18 to 30 months after that calibration, the system must have been intercompared with another dosimetry system that was calibrated within the past 24 months by NIST or by a calibration laboratory accredited by the AAPM. The results of the intercomparison must have indicated that the calibration factor of the licensee's system had not changed by more than 2 percent. The licensee may not use the intercomparison result to change the calibration factor. When intercomparing dosimetry systems to be used for calibrating sealed sources for therapeutic units, the licensee shall use a comparable unit with beam attenuators or collimators, as applicable, and sources of the same radionuclide as the source used at the licensee's facility.

b. The licensee shall have available for use a dosimetry system for spot-check output measurements, if applicable. To satisfy this requirement, the system may be compared with a system that has been calibrated in accordance with G.76a. This comparison must have

been performed within the previous year and after each servicing that may have affected system calibration. The spot-check system may be the same system used to meet the requirement in G.76a.

c. The licensee shall retain a record of each calibration, intercomparison, and comparison in accordance with G.111.

Sec. G.77 - Full Calibration Measurements on Teletherapy Units.

a. A licensee authorized to use a teletherapy unit for medical use shall perform full calibration measurements on each teletherapy unit:

   i. Before the first medical use of the unit; and

   ii. Before medical use under the following conditions:

      (1) Whenever spot-check measurements indicate that the output differs by more than 5 percent from the output obtained at the last full calibration corrected mathematically for radioactive decay;

      (2) Following replacement of the source or following reinstallation of the teletherapy unit in a new location;

      (3) Following any repair of the teletherapy unit that includes removal of the source or major repair of the components associated with the source exposure assembly; and

   iii. At intervals not exceeding 1 year.

b. To satisfy the requirement of G.77a., full calibration measurements must include determination of:

   i. The output within +/-3 percent for the range of field sizes and for the distance or range of distances used for medical use;

   ii. The coincidence of the radiation field and the field indicated by the light beam localizing device;

   iii. The uniformity of the radiation field and its dependence on the orientation of the useful beam;

   iv. Timer accuracy and linearity over the range of use;

   v. On-off error; and

   vi. The accuracy of all distance measuring and localization devices in medical use.

c. A licensee shall use the dosimetry system described in G.76a. to measure the output for one set of exposure conditions. The remaining radiation measurements required in G77b.i. may be made using a dosimetry system that indicates relative dose rates.

d. A licensee shall make full calibration measurements required by G.77a. in accordance with published protocols accepted by nationally recognized bodies.

e. A licensee shall mathematically correct the outputs determined in G.77b.i. for physical decay for intervals not exceeding 1 month for cobalt-60, 6 months for cesium-137, or at intervals consistent with 1 percent decay for all other nuclides.

f. Full calibration measurements required by G.77a. and physical decay corrections required by G.77e. must be performed by the authorized medical physicist.

g. A licensee shall retain a record of each calibration in accordance with G.112.

Sec. G.78 - Full Calibration Measurements on Remote Afterloader Units.

a. A licensee authorized to use a remote afterloader unit for medical use shall perform full calibration measurements on each unit:

   i. Before the first medical use of the unit;

   ii. Before medical use under the following conditions:

      (1) Following replacement of the source or following reinstallation of the unit in a new location outside the facility; and

      (2) Following any repair of the unit that includes removal of the source or major repair of the components associated with the source exposure assembly; and

   iii. At intervals not exceeding 1 quarter for high dose-rate, medium dose-rate, and pulsed dose-rate remote afterloader units with sources whose half-life exceeds 75 days; and

   iv. At intervals not exceeding 1 year for low dose-rate remote afterloader units.

b. To satisfy the requirement of G.78a., full calibration measurements must include, as applicable, determination of:

   i. The output within +/- 5 percent;

   ii. Source positioning accuracy to within +/- 1 millimeter;

   iii. Source retraction with backup battery upon power failure;

   iv. Length of the source transfer tubes;

v. Timer accuracy and linearity over the typical range of use;

vi Length of the applicators; and

vii. Function of the source transfer tubes, applicators, and transfer tube-applicator interfaces.

c. In addition to the requirements for full calibrations for low dose-rate remote afterloader units in G.78b., a licensee shall perform an autoradiograph of the source(s) to verify inventory and source(s) arrangement at intervals not exceeding one quarter.

d. A licensee shall use the dosimetry system described in G.76a. to measure the output.

e. A licensee shall make full calibration measurements required by G.78a. of this section in accordance with published protocols accepted by nationally recognized bodies.

f. For low dose-rate remote afterloader units, a licensee may use measurements provided by the source manufacturer that are made in accordance with G.78a. through G.78e.

g. A licensee shall mathematically correct the outputs determined in G.78b.i. for physical decay at intervals consistent with 1 percent physical decay.

h. Full calibration measurements required by G.78a. and physical decay corrections required by G.78g. must be performed by the authorized medical physicist.

i. A licensee shall retain a record of each calibration in accordance with G.112.

Sec. G.79 - Full Calibration Measurements on Gamma Stereotactic Radiosurgery Units.

a. A licensee authorized to use a gamma stereotactic radiosurgery unit for medical use shall perform full calibration measurements on each unit:

i. Before the first medical use of the unit;

ii. Before medical use under the following conditions:

(1) Whenever spot-check measurements indicate that the output differs by more than 5 percent from the output obtained at the last full calibration corrected mathematically for radioactive decay;

(2) Following replacement of the sources or following reinstallation of the gamma stereotactic radiosurgery unit in a new location; and

(3) Following any repair of the gamma stereotactic radiosurgery unit that includes removal of the sources or major repair of the components associated with the source assembly; and

iii. At intervals not exceeding 1 year, with the exception that relative helmet factors need only be determined before the first medical use of a helmet and following any damage to a helmet.

b. To satisfy the requirement of G.79a., full calibration measurements must include determination of:

i. The output within +/-3 percent;

ii. Relative helmet factors;

iii. Isocenter coincidence;

iv. Timer accuracy and linearity over the range of use;

v. On-off error;

vi. Trunnion centricity;

vii. Treatment table retraction mechanism, using backup battery power or hydraulic backups with the unit off;

viii. Helmet microswitchs;

ix. Emergency timing circuits; and

x. Stereotactic frames and localizing devices (trunnions).

c. A licensee shall use the dosimetry system described in G.76a. to measure the output for one set of exposure conditions. The remaining radiation measurements required in G.79b.i. may be made using a dosimetry system that indicates relative dose rates.

d. A licensee shall make full calibration measurements required by G.79a. in accordance with published protocols accepted by nationally recognized bodies.

e. A licensee shall mathematically correct the outputs determined in G.79b.i. at intervals not exceeding 1 month for cobalt-60 and at intervals consistent with 1 percent physical decay for all other radionuclides.

f. Full calibration measurements required by G.79a. and physical decay corrections required by G.79e. must be performed by the authorized medical physicist.

g. A licensee shall retain a record of each calibration in accordance with G.112.

Sec. G.80 - Periodic Spot-Checks for Teletherapy Units.

a. A licensee authorized to use teletherapy units for medical use shall perform output spot-

checks on each teletherapy unit once in each calendar month that include determination of:

i. Timer accuracy, and timer linearity over the range of use;

ii. On-off error;

iii. The coincidence of the radiation field and the field indicated by the light beam localizing device;

iv. The accuracy of all distance measuring and localization devices used for medical use;

v. The output for one typical set of operating conditions measured with the dosimetry system described in G.76b.; and

vi. The difference between the measurement made in G.80a.v. and the anticipated output, expressed as a percentage of the anticipated output (i.e., the value obtained at last full calibration corrected mathematically for physical decay).

b. A licensee shall perform measurements required by G.80a. in accordance with procedures established by the authorized medical physicist. That individual need not actually perform the spot check measurements.

c. A licensee shall have the authorized medical physicist review the results of each spot-check within 15 days. The authorized medical physicist shall promptly notify the licensee in writing of the results of each spot-check.

d. A licensee authorized to use a teletherapy unit for medical use shall perform safety spot-checks of each teletherapy facility once in each calendar month and after each source installation to assure proper operation of:

i. Electrical interlocks at each teletherapy room entrance;

ii. Electrical or mechanical stops installed for the purpose of limiting use of the primary beam of radiation (restriction of source housing angulation or elevation, carriage or stand travel and operation of the beam on-off mechanism);

iii. Source exposure indicator lights on the teletherapy unit, on the control console, and in the facility;

iv. Viewing and intercom systems;

v. Treatment room doors from inside and outside the treatment room; and

vi. Electrically assisted treatment room doors with the teletherapy unit electrical power turned off.

e. If the results of the checks required in G.80d. indicate the malfunction of any system, a

licensee shall lock the control console in the off position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

f. A licensee shall retain a record of each spot-check required by G.80a. and G.80d., in accordance with G.113.

Sec. G.81 - Periodic Spot-Checks for Remote Afterloader Units.

a. A licensee authorized to use remote afterloader units for medical use shall perform spot-checks of each remote afterloader facility and on each unit:

   i. At the beginning of each day of use of a high dose-rate, medium dose-rate or pulsed dose-rate remote afterloader unit;

   ii. Prior to each patient treatment with a low dose-rate remote afterloader unit; and

   iii. After each source installation.

b. The licensee shall have the authorized medical physicist establish written procedures for performing the spot-checks required in G.81a. The authorized medical physicist need not actually perform the spot-check measurements.

c. A licensee shall have the authorized medical physicist review the results of each spot-check within 15 days. The authorized medical physicist shall notify the licensee as soon as possible in writing of the results of each spot check.

d. To satisfy the requirements of G.81a., spot-checks must, at a minimum, assure proper operation of:

   i. Electrical interlocks at each remote afterloader unit room entrance;

   ii. Source exposure indicator lights on the remote afterloader unit, on the control console, and in the facility;

   iii. Viewing and intercom systems in each high dose-rate, medium dose-rate and pulsed dose-rate remote afterloader facility;

   iv. Emergency response equipment;

   v. Radiation monitors used to indicate the source position;

   vi. Timer accuracy;

   vii. Clock (date and time) in the unit's computer; and

   viii. Decayed source(s) activity in the unit's computer.

e. If the results of the checks required in G.81d. indicate the malfunction of any system, a licensee shall lock the control console in the off position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

f. A licensee shall retain a record of each check required by G.81d. in accordance with G.114.

Sec. G.82 - Periodic Spot-Checks for Gamma Stereotactic Radiosurgery Units.

a. A licensee authorized to use a gamma stereotactic radiosurgery unit for medical use shall perform spot-checks of each gamma stereotactic radiosurgery facility and on each unit:

   i. Monthly;

   ii. At the beginning of each day of use; and

   iii. After each source installation.

b. The licensee shall have the authorized medical physicist:

   i. Establish written procedures for performing the spot-checks required in G.82a.; and

   ii. Review the results of each spot-check required by G.82a.i. within 15 days of the check. The authorized medical physicist need not actually perform the spot-check measurements. The authorized medical physicist shall notify the licensee as soon as possible, in writing, of the results of the spot check.

c. To satisfy the requirements of G.82a.i., spot-checks must, at a minimum:

   i. Assure proper operation of:

      (1) Treatment table retraction mechanism, using backup battery power or hydraulic backups with the unit off;

      (2) Helmet microswitchs;

      (3) Emergency timing circuits; and

      (4) Stereotactic frames and localizing devices (trunnions).

   ii. Determine :

      (1) The output for one typical set of operating conditions measured with the dosimetry system described in G.76b.;

      (2) The difference between the measurement made in G.82c.ii.(1) and the anticipated output, expressed as a percentage of the anticipated output (i.e., the value obtained at last full calibration corrected mathematically for physical

decay);

(3) Source output against computer calculation;

(4) Timer accuracy and linearity over the range of use;

(5) On-off error; and

(6) Trunnion centricity.

d. To satisfy the requirements of G.82a.ii. and G.82a.iii., spot-checks must assure proper operation of:

i. Electrical interlocks at each gamma stereotactic radiosurgery room entrance;

ii. Source exposure indicator lights on the gamma stereotactic radiosurgery unit, on the control console, and in the facility;

iii. Viewing and intercom systems;

iv. Timer termination;

v. Radiation monitors used to indicate room exposures; and

vi. Emergency off buttons.

e. A licensee shall arrange for prompt repair of any system identified in G.82c. that is not operating properly.

f. If the results of the checks required in G.82d. indicate the malfunction of any system, a licensee shall lock the control console in the off position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

g. A licensee shall retain a record of each check required by G.82c. and G.82d. in accordance with G.115.

Sec. G.83 - Additional Technical Requirements for Mobile Remote Afterloader Units.

a. A licensee providing mobile remote afterloader service shall:

i. Check survey instruments for consistent response before medical use at each address of use or on each day of use, whichever is more frequent; and

ii. Account for all sources before departure from a client's address of use.

b. In addition to the periodic spot-checks required by G.81, a licensee authorized to use mobile afterloaders for medical use shall perform checks on each remote afterloader unit before use

at each address of use. At a minimum, checks must be made to verify the operation of :

i. Electrical interlocks on treatment area access points;

ii. Source exposure indicator lights on the remote afterloader unit, on the control console, and in the facility;

iii. Viewing and intercom systems;

iv. Applicators, source transfer tubes, and transfer tube-applicator interfaces;

v. Radiation monitors used to indicate room exposures;

vi. Source positioning (accuracy); and

vii. Radiation monitors used to indicate whether the source has returned to a safe shielded position.

c. In addition to the requirements for checks in G.83b., a licensee shall ensure overall proper operation of the remote afterloader unit by conducting a simulated cycle of treatment before use at each address of use.

d. If the results of the checks required in G.83b. indicate the malfunction of any system, a licensee shall lock the control console in the off position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

e. A licensee shall retain a record of each check required by G.83b. in accordance with G.116.

Sec. G.84 - Radiation Surveys.

a. In addition to the survey requirements in D.501 of these regulations, a person licensed pursuant to Part G shall make surveys to ensure that the maximum radiation levels and average radiation levels from the surface of the main source safe with the source(s) in the shielded position does not exceed the levels stated in the Sealed Source and Device Registry.

b. The licensee shall make the survey required by G.84a. at installation of a new source and following repairs to the source(s) shielding, the source(s) driving unit, or other electronic or mechanical component that could expose the source, reduce the shielding around the source(s), or compromise the radiation safety of the unit or the source(s).

c. A licensee shall retain a record of the radiation surveys required by G.84a. in accordance with G.117.

Sec. G.85 - Five-Year Inspection for Teletherapy and Gamma Stereotactic Radiosurgery Units.

a. A licensee shall have each teletherapy unit and gamma stereotactic radiosurgery unit fully inspected and serviced during source replacement or at intervals not to exceed 5 years,

whichever comes first, to assure proper functioning of the source exposure mechanism.

b. This inspection and servicing may only be performed by persons specifically licensed to do so by the Agency, an Agreement State, a Licensing State or the Nuclear Regulatory Commission.

c. A licensee shall keep a record of the inspection and servicing in accordance with G.118.

Sec. G.86 - Therapy-Related Computer Systems. The licensee shall perform acceptance testing on the treatment planning system in accordance with published protocols accepted by nationally recognized bodies. At a minimum, the acceptance testing must include, as applicable, verification of:

a. The source-specific input parameters required by the dose calculation algorithm;

b. The accuracy of dose, dwell time, and treatment time calculations at representative points;

c. The accuracy of isodose plots and graphic displays;

d. The accuracy of the software used to determine radioactive source positions from radiographic images; and

e. The accuracy of electronic transfer of the treatment delivery parameters to the treatment delivery unit from the treatment planning system.

[Sec. G.87 - Possession of Survey Instruments. A licensee authorized to use radioactive material in remote afterloader units, teletherapy units, and gamma stereotactic radiosurgery units shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1 microsievert (0.1 mrem) per hour to 500 microsieverts (50 mrems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range of 10 microsieverts (1 mrem) per hour to 10 millisieverts (1000 mrems) per hour. The instruments shall be operable and calibrated in accordance with G.33.]

Sec. G.88 - Training for Use of Remote Afterloader Units, Teletherapy Units, and Gamma Stereotactic Radiosurgery Units. Except as provided in G.29, the licensee shall require an authorized user of a sealed source for a use authorized under G.71 to be a physician who:

a. Is certified by a medical specialty board whose certification process includes all of the requirements in G.88b. and whose certification has been recognized by an Agreement State or the Nuclear Regulatory Commission;[*/] or

b. i. Has completed a structured educational program in basic radionuclide techniques applicable to the use of a sealed source in a therapeutic medical unit that includes:

(1) 200 hours of classroom and laboratory training in the following areas:

[*/] *Licensing State not included because compatibility B. State may want to recognize the Licensing State certification for NARM.*

(a) Radiation physics and instrumentation;

(b) Radiation protection;

(c) Mathematics pertaining to the use and measurement of radioactivity; and

(d) Radiation biology; and

ii. 500 hours of work experience, under the supervision of an authorized user who meets the requirements in G.88 or equivalent Agreement State or Nuclear Regulatory Commission requirements at a medical institution, involving:

(1) Reviewing full calibration measurements and periodic spot checks;

(2) Preparing treatment plans and calculating treatment doses and times;

(3) Using administrative controls to prevent a misadministration involving the use of radioactive material;

(4) Implementing emergency procedures to be followed in the event of the abnormal operation of the medical unit or console;

(5) Checking and using survey meters; and

(6) Selecting the proper dose and how it is to be administered; and

iii. Three years of supervised clinical experience in radiation oncology, under an authorized user who meets the requirements in G.88 or equivalent Agreement State or Nuclear Regulatory requirements, as part of a formal training program approved by the Residency Review Committee for Radiation Oncology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association. This experience may be obtained concurrently with the supervised work experience required by G.88b.ii.; and

iv. Has obtained written certification, signed by a preceptor authorized user, who meets the requirements in G.88, equivalent Agreement State or Nuclear Regulatory requirements, that the individual has satisfactorily completed the requirements in G.88b.i. and G.88b.ii. and has achieved a level of competency sufficient to independently function as an authorized user of the therapeutic medical unit for which the individual is requesting authorized user status.

Other Medical Uses of Radioactive Material or Radiation from Radioactive Material

Sec. G.89 - Other Medical Uses of Radioactive Material or Radiation From Radioactive Material.

A licensee may use radioactive material or a radiation source approved for medical use that is not specifically addressed in Part G if:

a. The applicant or licensee has submitted the information required by G.8b., G.8c. and G.8d.; and

b. The applicant or licensee has received written approval from the NRC, an Agreement State, or Licensing State in a license and uses the material in accordance with the regulations and specific conditions the NRC, Agreement State, or Licensing State considers necessary for the medical use of the material.

Records

Sec. G.90 - Records of Authority and Responsibilities for Radiation Protection Programs.

a. A licensee shall retain a record of actions taken by the licensee's management in accordance with G.18a. for 5 years. The record must include a summary of the actions taken and a signature of licensee management.

b. The licensee shall retain a current copy of the authorities, duties and responsibilities of the Radiation Safety Officer as required by G.18d., and a signed copy of the Radiation Safety Officer's agreement to be responsible for implementing the radiation safety program, as required by G.18b. The record must include the signature of the Radiation Safety Officer and licensee management.

c. [The minutes of each Radiation Safety Committee meeting held in accordance with G.18g. shall include:

   i. The date of the meeting;

   ii. Members present;

   iii. Members absent; and

   iv. Summary of deliberations and discussions.]

Sec. G.91 - Records of Radiation Protection Program Safety Changes. A licensee shall retain a record of each radiation protection program change made in accordance with G.19a. for 5 years. The record must include a copy of the old and new procedures; the effective date of the change; and the signature of the licensee management that reviewed and approved the change.

Sec. G.92 - Records of Written Directives. A licensee shall retain a copy of each written directive as required by G.22 for 3 years.

Sec. G.93 - Records of Misadministrations. A licensee shall retain a record of misadministrations reported in accordance with G.119 for 3 years. The record must contain the licensee's name; names

of the individuals involved; the social security number or other identification number if one has been assigned, of the individual who is the subject of the misadministration; a brief description of the event; why it occurred; the effect, if any, on the individual; the actions, if any, taken, or planned, to prevent recurrence; and, whether the licensee notified the individual (or the individual's responsible relative or guardian) and, if not, whether such failure to notify was based on guidance from the referring physician.

Sec. G.94 - Record of a Dose to an Embryo/Fetus or a Nursing Child.*/ A licensee shall retain a record of a dose to an embryo/fetus or a nursing child reported in accordance with G.120 for 3 years. The record must contain the licensee's name; names of all the individuals involved; social security number or other identification number if one has been assigned to the pregnant individual or nursing child who is the subject of the event; a brief description of the event; why it occurred; the effect, if any, on the embryo/fetus or nursing child; the actions, if any, taken, or planned, to prevent recurrence; and whether the licensee notified the pregnant individual or mother (or the mother's or child's responsible relative or guardian) and, if not, whether such failure to notify was based on guidance from the referring physician.

Sec. G.95 - Records of Calibrations of Instruments Used to Measure the Activity of Unsealed Radioactive Material. A licensee shall maintain a record of instrument calibrations required by G.32 for 3 years. The records must include the model and serial number of the instrument, the date of the calibration, the results of the calibration, and the name of the individual who performed the calibration.

Sec. G.96 - Records of Survey Instrument Calibrations. A licensee shall maintain a record of survey instrument calibrations required by G.33 for 3 years. The record must include the model and serial number of the instrument, the date of the calibration, the results of the calibration, and the name of the individual who performed the calibration.

Sec. G.97 - Records of Dosages of Unsealed Radioactive Material for Medical Use. A licensee shall maintain a record of dosage determinations required by G.34 for 3 years. The record must contain the radioactive drug; the patient's or human research subject's name, or identification number if one has been assigned; prescribed dosage; the determined dosage, or a notation that the total activity is less than 1.1 megabecquerel (30 μCi); the date and time of the dosage determination; and the name of the individual who determined the dosage.

Sec. G.98 - Records of Possession of Sealed Sources and Brachytherapy Sources. A licensee shall retain a record of the semi-annual physical inventory of sealed sources and brachytherapy sources required by G.36d. for 3 years. The inventory record must contain the model number of each source, and serial number if one has been assigned, the identity of each source radionuclide and its nominal activity, the location of each source, and the name of the individual who performed the inventory.

Sec. G.99 - Records of Surveys for Ambient Radiation Exposure Rate. A licensee shall retain a record of each survey required by G.39 for 3 years. The record must include the date of the survey, the results of the survey, the instrument used to make the survey, and the name of the individual who performed the survey.

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*/ *This rule may have health and safety implications, please see Rational for Part G 2002 for more information.*

Sec. G.100 - Records of the Release of Individuals Containing Radioactive Drugs or Implants Containing Radioactive Material.

a. A licensee shall retain a record, signed by the authorized user, of the basis for authorizing the release of an individual, for 3 years after the date of release.

b. A licensee shall retain a record, for 3 years after the date of release, that the instructions required by G.40b. were provided to a breast-feeding woman if the radiation dose to the infant or child from continued breast-feeding could result in a total effective dose equivalent exceeding 1 millisievert (0.1 rem).

[b. A licensee shall retain a record, for 3 years after the date of release, that the instructions required by G.40b. were provided to a breast-feeding woman.]

Sec. G.101 - Records of Administrative and Technical Requirements that Apply to the Provision of Mobile Services.

a. A licensee shall retain a copy of the letter(s) that permits the use of radioactive material at a client's address of use, as required by G.9b., for 3 years after the last provision of service.

b. A licensee shall retain the record of each survey required by G.41f. for 3 years. The record must include the date of the survey, the results of the survey, the instrument used to make the survey, and the name of the individual who performed the survey.

Sec. G.102 - Records of Decay-in-Storage. A licensee shall maintain records of the disposal of licensed materials, as required by G.43, for 3 years. The record must include the date of the disposal, the survey instrument used, the background radiation level, the radiation level measured at the surface of each waste container, and the name of the individual who performed the survey.

Sec. G.103 - Records of Radionuclide Purity. A licensee shall maintain a record of the radionuclide contaminant concentration tests required by G.48 for 3 years. The record must include, for each measured elution of radionuclide used to prepare a radioactive drug, the ratio of the measures expressed as kilobecquerel of contaminant per megabecquerel of desired radionuclide (microcuries/millicurie), or microgram of contaminant per megabecquerel of desired radionuclide (microgram/millicurie), the time and date of the measurement, and the name of the individual who made the measurement.

[Sec. G.104 - Records of Training. A licensee shall maintain records of training required by G.28 for 3 years after the last date an individual was authorized to act as a nuclear medicine technologist or radiation therapist at the licensee's facility.]

Sec. G.105 - Records of Safety Instruction and Training. A licensee shall maintain a record of safety instructions and training required by G.53, G.62 and G.74 for 3 years. The record must include a list of the topics covered, the date of the instruction or training, the name(s) of the attendee(s), and the name(s) of the individual(s) who provided the instruction.

Sec. G.106 - Records of Radiation Surveys of Patients and Human Research Subjects. A licensee shall maintain a record of the surveys required by G.60 and G.72 for 3 years. Each record must include the date and results of the survey, the survey instrument used, and the name of the individual who made the survey.

Sec. G.107 - Records of Brachytherapy Source Inventory.

a. A licensee shall maintain a record of brachytherapy source accountability required by G.61 for 3 years.

b. For temporary implants, the record must include:

   i. The number and activity of sources removed from storage, the time and date they were removed from storage, the name of the individual who removed them from storage, and the location of use; and

   ii. The number and activity of sources not implanted, the time and date they were returned to storage, and the name of the individual who returned them to storage.

c. For permanent implants, the record must include:

   i. The number and activity of sources removed from storage, the date they were removed from storage, and the name of the individual who removed them from storage;

   ii. The number and activity of sources returned to storage, the date they were returned to storage, and the name of the individual who returned them to storage; and

   iii. The number and activity of sources permanently implanted in the patient or human research subject.

Sec. G.108 - Records of Calibration Measurements on Brachytherapy Sources. A licensee shall maintain a record of the calibrations on brachytherapy sources required by G.64 for 3 years after the last use of the source. The record must include the date of the calibration; the manufacturer's name, model number, and serial number for the source and the instruments used to calibrate the source; the source output or activity; source positioning accuracy within applicators; and the signature of the authorized medical physicist.

Sec. G.109 - Records of Decay of Strontium-90 Sources for Ophthalmic Treatments. The licensee shall maintain a record of the activity of a strontium-90 source required by G.64 for the life of the source. The record must include the date and initial activity of the source as determined under G.64, and for each decay calculation, the date, the source activity and the signature of the authorized medical physicist.

Sec. G.110 - Records of Installation, Maintenance, Adjustment, and Repair. A licensee shall retain a record of the installation, maintenance, adjustment, and repair of remote afterloader units,

teletherapy units, and gamma stereotactic radiosurgery units as required by G.73 for 3 years. For each installation, maintenance, adjustment and repair, the record must include the date, description of the service, and name(s) of the individual(s) who performed the work.

Sec. G.111 - Records of Dosimetry Equipment.

a. A licensee shall retain a record of the calibration, intercomparison, and comparisons of its dosimetry equipment done in accordance with G.76 for the duration of the license.

b. For each calibration, intercomparison, or comparison, the record must include:

   i. The date;

   ii. The manufacturer's name, model numbers and serial numbers of the instruments that were calibrated, intercompared, or compared as required by G.76a. and G.76b.;

   iii. The correction factor that was determined from the calibration or comparison or the apparent correction factor that was determined from an intercomparison; and

   iv. The names of the individuals who performed the calibration, intercomparison, or comparison.

Sec. G.112 - Records of Teletherapy, Remote Afterloader, and Gamma Stereotactic Radiosurgery Full Calibrations.

a. A licensee shall maintain a record of the teletherapy, remote afterloader, and gamma stereotactic radiosurgery full calibrations required by G.77, G.78 and G.79 for 3 years.

b. The record must include:

   i. The date of the calibration;

   ii. The manufacturer's name, model number, and serial number for the teletherapy, remote afterloader, and gamma stereotactic radiosurgery unit(s), the source(s), and instruments used to calibrate the unit;

   iii. The results and assessments of the full calibrations;

   iv. The results of the autoradiograph required for low dose-rate remote afterloader units; and

   v. The signature of the authorized medical physicist who performed the full calibration.

Sec. G.113 - Records of Periodic Spot-Checks for Teletherapy Units.

a. A licensee shall retain a record of each periodic spot-check for teletherapy units required by G.80 for 3 years.

b. The record must include:

i. The date of the spot-check;

ii. The manufacturer's name, model number, and serial number for the teletherapy unit, source and instrument used to measure the output of the teletherapy unit;

iii. An assessment of timer linearity and constancy;

iv. The calculated on-off error;

v. A determination of the coincidence of the radiation field and the field indicated by the light beam localizing device;

vi. The determined accuracy of each distance measuring and localization device;

vii. The difference between the anticipated output and the measured output;

viii. Notations indicating the operability of each entrance door electrical interlock, each electrical or mechanical stop, each source exposure indicator light, and the viewing and intercom system and doors; and

ix. The name of the individual who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

Sec. G.114 - Records of Periodic Spot-Checks for Remote Afterloader Units.

a. A licensee shall retain a record of each spot-check for remote afterloader units required by G.81 for 3 years.

b. The record must include, as applicable:

i. The date of the spot-check;

ii. The manufacturer's name, model number, and serial number for the remote afterloader unit and source;

iii. An assessment of timer accuracy;

iv. Notations indicating the operability of each entrance door electrical interlock, radiation monitors, source exposure indicator lights, viewing and intercom systems, and clock and decayed source activity in the unit's computer; and

v. The name of the individual who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

Sec. G.115 - Records of Periodic Spot-Checks for Gamma Stereotactic Radiosurgery Units.

a. A licensee shall retain a record of each spot-check for gamma stereotactic radiosurgery units required by G.82 for 3 years.

b. The record must include:

i. The date of the spot-check;

ii. The manufacturer's name, model number, and serial number for the gamma stereotactic radiosurgery unit and the instrument used to measure the output of the unit;

iii. An assessment of timer linearity and accuracy;

iv. The calculated on-off error;

v. A determination of trunnion centricity;

vi. The difference between the anticipated output and the measured output;

vii. An assessment of source output against computer calculations;

viii. Notations indicating the operability of radiation monitors, helmet microswitchs, emergency timing circuits, emergency off buttons, electrical interlocks, source exposure indicator lights, viewing and intercom systems, timer termination, treatment table retraction mechanism, and stereotactic frames and localizing devices (trunnions); and

ix. The name of the individual who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

Sec. G.116 - Records of Additional Technical Requirements for Mobile Remote Afterloader Units.

a. A licensee shall retain a record of each check for mobile remote afterloader units required by G.83 for 3 years.

b. The record must include:

i. The date of the check;

ii. The manufacturer's name, model number, and serial number of the remote afterloader unit;

iii. Notations accounting for all sources before the licensee departs from a facility;

iv. Notations indicating the operability of each entrance door electrical interlock, radiation monitors, source exposure indicator lights, viewing and intercom system, applicators and source transfer tubes, and source positioning accuracy; and

v. The signature of the individual who performed the check.

Sec. G.117 - Records of Surveys of Therapeutic Treatment Units.

a. A licensee shall maintain a record of radiation surveys of treatment units made in accordance with G.84 for the duration of use of the unit.

b. The record must include:

i. The date of the measurements;

ii. The manufacturer's name, model number and serial number of the treatment unit, source, and instrument used to measure radiation levels;

iii. Each dose rate measured around the source while the unit is in the off position and the average of all measurements; and

iv. The signature of the individual who performed the test.

Sec. G.118 - Records of 5-Year Inspection for Teletherapy and Gamma Stereotactic Surgery Units.

a. A licensee shall maintain a record of the 5-year inspections for teletherapy and gamma stereotactic radiosurgery units required by G.85 for the duration of use of the unit.

b. The record must contain:

i. The inspector's radioactive materials license number;

ii. The date of inspection;

iii. The manufacturer's name and model number and serial number of both the treatment unit and source;

iv. A list of components inspected and serviced, and the type of service; and

v. The signature of the inspector.

Reports

Sec. G.119 - Reports and Notifications of Misadministrations.

a. Other than events that result from intervention by a patient or human research subject, a licensee shall report any event in which the administration of radioactive material or radiation from radioactive material results in:

i. A dose that differs from the prescribed dose by more than 0.05 Sievert (5 rem) effective dose equivalent, 0.5 Sievert (50 rem) to an organ or tissue, or 0.5 Sievert (50 rem) shallow dose equivalent to the skin; and either

(1) The total dose delivered differs from the prescribed dose by 20 percent or more;

(2) The total dosage delivered differs from the prescribed dosage by 20 percent or more or falls outside the prescribed dosage range; or

(3) The fractionated dose delivered differs from the prescribed dose, for a single fraction, by 50 percent or more.

ii. A dose that exceeds 0.05 Sievert (5 rem) effective dose equivalent, 0.5 Sievert (50 rem) to an organ or tissue, or 0.5 Sievert (50 rem) shallow dose equivalent to the skin from any of the following:

(1) An administration of a wrong radioactive drug;

(2) An administration of a radioactive drug containing radioactive material by the wrong route of administration;

(3) An administration of a dose or dosage to the wrong individual or human research subject;

(4) An administration of a dose or dosage delivered by the wrong mode of treatment; or

(5) A leaking sealed source.

iii. A dose to the skin or an organ or tissue other than the treatment site that exceeds by 0.5 Sievert (50 rem) to an organ or tissue and 50 percent of the dose expected from the administration defined in the written directive (excluding, for permanent implants, seeds that were implanted in the correct site but migrated outside the treatment site).

b. A licensee shall report any event resulting from intervention of a patient or human research subject in which the administration of radioactive material or radiation from radioactive material results, or will result in, unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

c. The licensee shall notify the Agency by telephone no later than the next calendar day after discovery of the misadministration.

d. The licensee shall submit a written report to the Agency within 15 days after discovery of the misadministration.

i. The written report must include:

(1) The licensee's name;

(2) The name of the prescribing physician;

(3) A brief description of the event;

(4) Why the event occurred;

(5) The effect, if any, on the individual(s) who received the administration;

(6) Actions, if any, that have been taken, or are planned, to prevent recurrence;

(7) Certification that the licensee notified the individual (or the individual's responsible relative or guardian), and if not, why not.

ii. The report may not contain the individual's name or any other information that could lead to identification of the individual.

e. The licensee shall provide notification of the misadministration to the referring physician and also notify the individual who is the subject of the misadministration no later than 24 hours after its discovery, unless the referring physician personally informs the licensee either that he or she will inform the individual or that, based on medical judgment, telling the individual would be harmful. The licensee is not required to notify the individual without first consulting the referring physician. If the referring physician or the affected individual cannot be reached within 24 hours, the licensee shall notify the individual as soon as possible thereafter. The licensee may not delay any appropriate medical care for the individual, including any necessary remedial care as a result of the misadministration, because of any delay in notification. To meet the requirements of this paragraph, the notification of the individual who is the subject of the misadministration may be made instead to that individual's responsible relative or guardian. If a verbal notification is made, the licensee shall inform the individual, or appropriate responsible relative or guardian, that a written description of the event can be obtained from the licensee upon request. The licensee shall provide such a written description if requested.

f. Aside from the notification requirement, nothing in this section affects any rights or duties of licensees and physicians in relation to each other, to individuals affected by the misadministration, or to that individual's responsible relatives or guardians.

g. A licensee shall retain a record of a misadministration in accordance with G.93. A copy of the record required under G.93 shall be provided to the referring physician if other than the licensee, within 15 days after discovery of the misadministration.

Sec. G.120 - Report and Notification of a Dose to an Embryo/Fetus or a Nursing Child.*/

a. A licensee shall report any dose to an embryo/fetus that is greater than 5 millisievert (500 mrem) dose equivalent that is a result of an administration of radioactive material or radiation from radioactive material to a pregnant individual unless the dose to the embryo/fetus was specifically approved, in advance, by the authorized user.

b. A licensee shall report any dose to a nursing child, that was not specifically approved, in advance, by the authorized user, that is a result of an administration of radioactive material to a breast feeding individual that:

   i. Is greater than 5 millisievert (500 mrem) total effective dose equivalent; or

   ii. Has resulted in unintended permanent functional damage to an organ or a physiological system of the child, as determined by a physician.

c. The licensee shall notify by telephone the Agency no later than the next calendar day after discovery of a dose to the embryo/fetus or nursing child that requires a report in G.120a. or G.120b.

d. The licensee shall submit a written report to the Agency within 15 days after discovery of a dose to the embryo/fetus or nursing child that requires a report in G.120a. or G.120b.

   i. The written report must include:

      (1) The licensee's name;

      (2) The name of the prescribing physician;

      (3) A brief description of the event;

      (4) Why the event occurred;

      (5) The effect on the embryo/fetus or the nursing child;

      (6) What actions, if any, have been taken, or are planned, to prevent recurrence; and

      (7) Certification that the licensee notified the pregnant individual or mother (or the mother's or child's responsible relative or guardian), and if not, why not.

   ii. The report must not contain the individual's or child's name or any other information

*/ *This rule may have health and safety implications, please see 2002 Rational for Part G for more information.*

that could lead to identification of the individual or child.

e. The licensee shall notify the referring physician and also notify the pregnant individual or mother, both hereafter referred to as the mother, no later than 24 hours after discovery of an event that would require reporting under G.120a. or G.120b., unless the referring physician personally informs the licensee either that he or she will inform the mother or that, based on medical judgment, telling the mother would be harmful. The licensee is not required to notify the mother without first consulting with the referring physician. If the referring physician or mother cannot be reached within 24 hours, the licensee shall make the appropriate notifications as soon as possible thereafter. The licensee may not delay any appropriate medical care for the embryo/fetus or for the nursing child, including any necessary remedial care as a result of the event, because of any delay in notification. To meet the requirements of this paragraph, the notification may be made to the mother's or child's responsible relative or guardian instead of the mother, when appropriate. If a verbal notification is made, the licensee shall inform the mother, or the mother's or child's responsible relative or guardian, that a written description of the event can be obtained from the licensee upon request. The licensee shall provide such a written description if requested.

f. A licensee shall retain a record of a dose to an embryo/fetus or a nursing child in accordance with G.94. A copy of the record required under G.94 shall be provided to the referring physician, if other than the licensee, within 15 days after discovery of the event.

Sec. G.121 - Reports of Leaking Sources. A licensee shall file a report with the Agency within 5 days if a leakage test required by G.36 reveals the presence of 185 Becquerel (0.005 μCi) or more of removable contamination. The written report must include the model number and serial number if assigned, of the leaking source; the radionuclide and its estimated activity; the results of the test; the date of the test; and the action taken.

Sec. G.122 - Reports of Patient Departure Prior to Authorized Release.

a. The licensee shall notify the Agency by telephone immediately upon discovery that a patient or human research subject has departed from the licensee's facility without authorization under G.40a.

b. The licensee shall submit a written report to the Agency within 30 days after discovery of the unauthorized departure. The written report must include:

   i. The licensee's name;

   ii. The date and time of the unauthorized departure;

   iii. The projected date and time when release would have occurred;

   iv. The address of the patient's or human research subject's home or anticipated destination following departure;

   v. The radionuclide, chemical and physical form and calculated activity at time of

release;

vi. The apparent reason(s) for the departure prior to authorized release; and

vii. A description of any changes in the licensee's patient release criteria or patient instructions that are designed to avoid a recurrence of such an event.

Sec. G.123 - Notification of Deceased Patients or Human Research Subjects Containing Radioactive Material.

a. The licensee shall notify the Agency by telephone immediately upon discovery that a patient or human research subject containing radioactive material has died, and it is possible that any individual could receive exposures in excess of Part D.301 of these regulations as a result of the deceased's body.

b. The licensee shall submit a written report to the Agency within 30 days after discovery that the patient or human research subject referenced in G.120a. has died. The written report must include:

i. The licensee's name;

ii. The date of death;

iii. The radionuclide, chemical and physical form and calculated activity at time of death; and,

iv. The names (or titles) and address(es) of known individuals who might have received exposures exceeding 5 millisieverts (500 mrem).

2002 Rationale

Part G

Use of Radionuclides in the Healing Arts

Introduction

After numerous comment periods, which included comments and recommendations made at public meetings during 1998 and 1999, the U.S. Nuclear Regulatory Commission published the final revision of 10CFR Part 35 in the Federal Register on April 24, 2002, and its effective date is October 24, 2002.

The new Part 35 includes the following changes:

1. A move toward more "risk-informed, performance-based" regulations.

2. Dropping the requirement that a licensee submit all required written procedures for review by the Agency.

3. Addition of a rule that requires the licensee to report a dose equivalent greater than 50 millisievert (5 rem) to an embryo/fetus or nursing infant which is the result of administration of radioactive material or radiation from radioactive material to a pregnant individual or nursing mother. **Please see discussion section.**

4. Addition of rules for high-dose-rate, pulsed-dose-rate and low-dose-rate remote afterloaders, and gamma stereotactic radiosurgery imaging units.

5. Dropping the requirement that all medical institutions must have a Radiation Safety Committee.

6. More stringent training and experience requirements for authorized users of unsealed radioactive material for therapy (with the exception of oral sodium I-131 users).

7. Less restrictive training and experience requirements for authorized users of oral sodium I-131 in activities less than 33 mCi. **Please see discussion section.**

8. Addition of rules for the regulation of new medical uses of radioactive material (See G.89).

9. Inclusion of the requirement that the preceptor authorized user must submit written certification that the individual has achieved a level of competency sufficient to independently function as an authorized user for the medical uses requested. **Please see discussion section.**

10. Less reiteration of rules that are also found in other parts (such as 10CFR Part 20).

Specific Considerations

I. Discussion

Because of the major changes made to 10 CFR Part 35, the equivalent Part G of the Suggested State Regulations for the Control of Radiation (SSRCR) was revised in its entirety. If adopted as written, Part G will be compatible with NRC Part 35.

Radiation Safety Committee Requirements

The revised Part 35 no longer requires a licensee to establish a radiation safety committee unless the licensee is authorized for two or more different types of uses of byproduct material under Subparts E, F, and H, or two or more types of uses under Subpart H. The rule specifies who must be represented on the committee, but nothing else.

The committee considered this rule change, and has adopted it. However, we have also included bracketed text (G.18g) which specifies the minimum number of times each year (as little as once) the committee must meet and requirements for the maintenance of minutes for each meeting (G.90). The committee recommends adoption of these bracketed sections. This rule has been designated as a compatibility category H&S, therefore an Agency may adopt the more restrictive text if they wish.

Training and Experience Requirements

During meetings conducted during the rule making process, members of the Advisory Committee on Medical Uses of Isotopes (ACMUI) indicated that the NRC's proposed revisions for training and experience appeared acceptable. However, the ACMUI notified the NRC during their February, 2002 meeting that the NRC's proposed training and experience requirements were inaccurate. Specifically, some of the certifying entities stated that they do not require an individual to meet the supervised clinical experience section of the NRC's proposed rules to sit for their board exams. Based on the ACMUI's statements, the NRC has established a two year transition period within which the old Subpart J (35.900) series training and experience requirements will be retained. During this two year period, the NRC will determine whether revisions to the new training and experience rules are necessary, and if so, will prepare them for implementation. The transition period will begin on the effective date of the rule. For Agreement States, the two year transition period is concurrent with the three year compatibility requirement, not consecutive. The NRC states that for purposes of compatibility, Agreement States should adopt the revised rule in its entirety, recognizing that the current training and experience requirements (the old Subpart J) are compatibility category D, and any revised training and experience requirements (which will go into effect on or before October 24, 2004) are compatibility category B.

The committee has considered these statements in revising Part G. Regarding the NRC's statements about adoption of the revised training and experience requirements, the committee believes that, for the most part, the revised criteria are appropriate. We therefore have included the revised training and experience rules in this revision of Part G.

Under these rules, new Radiation Safety Officers, authorized medical physicists, authorized nuclear pharmacists, and authorized users may be certified by a specialty board whose certification process includes all of the training, experience, and written, signed preceptor certification requirements of that section of the rules, and whose certification process has been recognized by the NRC or an

Agreement State. Specialty boards are not listed by name in the rule text so as to allow additions, deletions, and amendments in the recognized list without a rule revision. A list of recognized boards is to be maintained by the NRC on their web site. If a Radiation Safety Officer, authorized medical physicist, authorized nuclear pharmacist or authorized user is not certified by a recognized board, they must submit evidence that they have completed the required training and experience sections of the rule along with a written preceptor certification. The written certification, signed by an appropriate preceptor, indicates that the individual has satisfactorily completed the required didactic and supervised clinical requirements of the rules, and has achieved a level of competency or radiation safety knowledge sufficient to function independently in their requested duties.

While the committee does agree with the majority of the changes made by the NRC for training and experience requirements, we wish to discuss two sections which the NRC has added.

Training for Authorized Users of Oral Sodium Iodine 131.

Rules G.57 and G.58 correspond to NRC 35.392 and 35.394. These rules describe the training and experience requirements for authorized users of oral sodium I-131 only. If the route of administration or chemical form is anything other than oral sodium iodine 131, the authorized user must meet the training requirements specified in G.56. G.56 is an all new rule which requires authorized users to receive a total of 700 hours of classroom/laboratory training and work experience, as well as supervised clinical experience administering dosages of radioactive drugs in a minimum of three cases in each of the categories for which the individual is requesting authorized user status. The previous Part 35 rules required the prospective authorized user to obtain 80 hours of didactic radiation safety training, as well as supervised clinical experience (3 cases for treatment of thyroid carcinoma and 10 cases for treatment of hyperthyroidism or cardiac dysfunction).

The NRC's new 35.392 (G.57) and 35.394 (G.58) carry over the 80 hours of didactic radiation safety training, but they drop the number of cases of supervised clinical experience for the treatment of hyperthyroidism from 10 to 3.

The NRC has reclassified all revised training and experience rules from a compatibility category D to a compatibility category B. Category B classifications are for "activities that have direct and significant transboundary implications". The committee failed to see any clear transboundary implications, and requested clarification from the NRC. In their response, the NRC stated, "On balance, the Commission determined that T&E requirements represent significant transboundary issues that have direct and significant effects in multiple jurisdictions. Therefore, the Commission followed the 1997 Policy in determining that compatibility Category B is more appropriate than Category C for the T&E requirements in Part 35 to ensure consistency between NRC and the Agreement States. State action to adopt more restrictive T&E requirements could create nonuniformity and inconsistency in the provision of medical services across State boundaries and result in increased costs to the national healthcare delivery system. This is true, not just for nuclear medicine licensees, but for all authorized users of byproduct material in Part 35."

While the committee understands that any regulation of licensed material may increase the cost of business or services offered by a licensee, the increased health and safety that results from a regulation can, and should, offset the increased costs.

In the opinion of the committee, these rules do not appear to meet the NRC criteria of "risk-informed, performance-based" regulations. While an authorized user of diagnostic

radiopharmaceuticals for imaging and localization studies is required to receive at least 700 hours of didactic training and supervised clinical experience, both 35.392 (G.57) and 35.394 (G.58) only require the authorized user to receive at least 80 hours of didactic training, and supervised work experience in the form of 3 cases involving the oral administration of sodium I-131. The committee believes that the use of oral sodium I-131 carries a much higher radiation safety risk to the patient, occupationally exposed workers, ancillary personnel and the public than any diagnostic use. In fact, we feel it carries a higher risk than the use of other common therapy radiopharmaceuticals, including others containing iodine 131.

During this rulemaking process, a review of the NRC's Nuclear Material Events Database (NMED) was made. Data for medical use of unsealed radioactive material was reviewed for the time period of January 1, 1989 through May 3, 2002. During this period there were 107 events that were reportable, but did not meet the abnormal occurrence criteria. Of these, one involved I-123 (0.9%), two involved Sr-89 (1.9%), two involved unsealed I-125 (1.9%), four involved Sm-153 (3.7%), four involved unsealed P-32 (3.7%), and ninety-four involved I-131 (88%).

Of the thirty-nine reported abnormal occurrences which were the result of incorrect doses to patients (wrong patient, wrong radiopharmaceutical or wrong dose) between January 1, 1989 and May 3, 2002, one involved Sm-153 (2.5%), one involved Sr-89 (2.5%), two involved P-32 (5%), and thirty-five involved I-131 (90%).

The NRC made additional statements regarding the use of NMED data in their response to our request for clarification. In their letter, the NRC states, "We do not agree that the Abnormal Occurrence Reports (AOR) support the need for more training for authorized users of Sodium Iodide-131. It should be recognized, that based on a review of AOR data, the majority of Sodium Iodide-131 medical misadministrations occur in hospitals where physicians typically exceed minimum T&E requirements versus freestanding facilities or private offices where physicians meet minimum T&E requirements. The historic AOR data does not support, based on health and safety considerations including the low probability of such events, an increase in T&E requirements for these or any other category of authorized user. After careful consideration of this complex issue, the Commission arrived at a consensus that, in its judgment, there is a greater benefit to uniformity and consistency, nationwide, in applying compatibility Category B rather than Category C to Agreement State T&E requirements."

In the committee's opinion, the risk involved to the patient, occupationally exposed worker and the public warrants increased training and experience requirements.

Based on the high degree of risk and previous misadministration and abnormal occurrence data involving oral sodium I-131, it is the committee's opinion that users of oral sodium I-131 should also be required to receive 700 hours of classroom/laboratory training and work experience, and three supervised cases of clinical experience with oral sodium I-131. **However, in order to maintain compatibility with the NRC, you must adopt both G.57 and G.58.**

In addition, you should note that the NRC rule text for 35.390(b)(1)(ii)(G)(3) and (4) covers only supervised clinical experience gained in the parenteral administration of isotopes. Therefore, the supervised clinical experience cannot include the oral administration of any isotopes other than the sodium iodide 131 covered in 35.390(b)(1)(ii)(G)(1) and (2).

Patient Release Rule (G.40b.)

Several questions have arisen since the NRC adopted the patient release rule (35.75). For instance, why is it appropriate to allow a member of the general public to receive a 500 mrem exposure from a released patient, when they cannot receive any more than a 100 mrem exposure from any other licensed or registered activity? How do you handle individuals, such as home health nurses, nurses aides and nursing home staff, who in one year, may come into contact with numerous patients who have been released in accordance with 35.75? They might easily exceed 500 mrem TEDE during that year. What does an Agency do with recovered waste that is the result of a released patient?

There is no way of knowing with certainty if the release of a patient will result in excessive or unnecessary exposures to the public. There have been studies that show that any exposures occurring from released patients are less than 500 mrem. However, these are not blinded studies. The committee believes if a licensee uses appropriate radiation safety and health physics factors in deciding if a patient can be released, and if the patient and their family receive, and follow, adequate oral and written radiation safety instruction, radiotherapy patients can be released and result in minimal radiation exposures to the public. To assist Agencies in maintaining public exposures ALARA, the committee has a number of recommendations for this rule.

The NRC rule requires the licensee to provide additional instructions, including written instructions, to a released individual on actions recommended to maintain doses to other individuals ALARA, if the TEDE to any other individual could exceed 1 millisievert (100 mrem). The rule text in G.40b. and G.100b. is the same as that found in 35.75(b) and 35.2075(b). However, the committee believes that all patients should receive oral and written instructions when they are released. For that reason, the committee recommends that the optional, bracketed rule text in G.40b. and G.100b. be adopted.

The committee also recommends the inclusion of three additional sections to G.40 that we believe will enhance radiation safety. These sections are bracketed in the revised Part G as sections G.40c., G.40g. and G.40h.

The recommended G.40c. requires that an authorized user approve the release of the patient. The committee believes that an authorized user physician familiar with the type of radioactive material use the patient under went should give final approval for their release. This also keeps an authorized user informed of any releases, and any radiological basis for authorizing the release of the patient.

The recommended G.40g. requires the licensee to notify the Agency if a patient departs prior to an authorized release. Physicians and hospitals cannot hold a patient against their will. The committee believes that the Agency should be aware of individuals in the public domain that could result in exposures to members of the general public exceeding 500 mrem.

The recommended G.40h. requires the licensee to notify the Agency when they become aware of the death of a released patient containing radioactive material whose body might expose an individual member of the public to greater than a 500 mrem exposure.

Because only NRC 35.75(a) and (b) have been assigned a compatibility category C, and 35.2075(b) has been assigned a compatibility category D, an Agreement State can adopt the above recommended bracketed text without jeopardizing compatibility.

Besides the above described three sections that the Committee believes will improve radiation safety, the committee has also included optional, bracketed text (G.40f.) that can assist the Agency in the proper disposal of radioactive waste, traceable to the licensee as its origin, that is discovered in a solid waste stream.

Records of Doses to an Embryo/Fetus or a Nursing Child (G.94 and G.120)

These rules (corresponding to 35.3047) describe the record and reporting requirements for a licensee should an embryo/fetus or nursing child receive a dose equivalent greater than 50 millisievert (5 rem). The NRC included this rule to help alleviate the number of reports that a licensee must submit as the result of a nursing child exceeding the dose limits of Part 20 (5 millisieverts or 500 mrem) when a nursing individual receives a diagnostic dosage, and to include embryo/fetuses in the reporting requirements. The NRC rule text does not specifically approve 5 rem TEDE exposures to the embryo/fetus or nursing infant, and is not intended to be an exception to Part 20 dose limits. Embryos and fetuses are not considered members of the public. With the exception of declared pregnant occupationally exposed individuals, there are no exposure limits to the embryo/fetus specified in the rules. The limit for the declared pregnant individual is 5 millisieverts (500 mrem) to the embryo/fetus over the entire term of the pregnancy. But because there are no such limits for non-occupationally exposed individuals, 35.3047 has effectively set the exposure limit at the level of the reporting requirement (50 millisievert or 5000 mrem). Unfortunately, this exception to the reporting requirements also appears to give tacit approval for such exposures to nursing children. In addition, the NRC rule adds to the already confusing number of dose limit and reporting requirements of Part 20.

While the committee agrees, in part, with the intent of this rule, we believe that accidental exposures above the 500 mrem limits to the embryo/fetus and nursing child should be reported. We believe the radiosensitivity of the embryo/fetus and developing child warrant such requirements.

The NRC has assigned a compatibility category C to 35.3047, therefore Agreement States can be more restrictive than the NRC. The committee has included rules G.94 and G.120, but has lowered the reporting level to 500 mrem. Doses exceeding 500 mrem to a nursing child should not occur if the patient is properly questioned and instructed. And it should be noted that Part D rules allow a trained authorized user to knowingly approve any amount of exposure to the embryo/fetus if, through the use of their medical and radiation safety knowledge, they decide the risk is justified.

There are other areas of Part G that are more restrictive than, or in addition to, NRC Part 35 requirements. Descriptions of these rule texts follow.

There are a number of differences or additions in the definitions section. None of these differences will affect compatibility. These differences are specified below.

The committee added a definition for "Accredited institution" that is only necessary if the Agency adopts the training and experience requirements for nuclear medicine technologists and radiation therapists (G.28).

The NRC changed the term "misadministration" to "medical event". The committee has not adopted this change. The committee sees any medical action taken toward or on behalf of the patient or human research subject as being a medical event. We feel the term "misadministration" is much clearer and more appropriate.

The committee has added the words "or equal to" in the definition of "medium dose-rate remote afterloader" so that a dose equal to 12 gray (1200 rads) per hour is not excluded in the definitions.

Because the committee included minimum training and experience criteria for nuclear medicine technologists and radiation therapists, definitions of "nuclear medicine technologist", "nuclear medicine technology", "radiation therapist" and "radiation therapy technology" have been added.

The NRC has much broader definitions for "Dentist", "Pharmacist", "Physician" and "Podiatrist" because there is no national authority to license these individuals, and the NRC's jurisdiction crosses state lines. But because these individuals must be licensed to practice their chosen profession by the appropriate authority in each state, the Part G definitions reflect this.

Part G requires the licensee to submit required written procedures for review by the Agency. The NRC does not require all required written procedures to be submitted for review. They intend to review such procedures only when a problem is found during an inspection that should have been addressed by one of these required procedures. The committee believes that it is better to determine the adequacy of a written procedure before a problem occurs. Waiting until after a problem occurs to review written procedures is reactive, not pro-active, and the committee doesn't believe this is in the best radiation safety interest of patients or occupational workers. What's more, the review and discussion of a written procedure opens the lines of communication, and allows the building of a rapport between the licensee and the regulating agency. It can also increase the confidence of both parties in the resultant radiation safety program.

We have added Sec. G.9 - Mobile Medical Service Administration Requirements. Paragraphs b. and c. correspond to NRC 35.80(a)(1) and (b), respectively. The committee moved these licensing requirements to this section because we felt it made the rule easier to follow and more clear.

During formulation of the new Part G, the committee found that some states had adopted the NRC's decision to drop requirements to amend the license before allowing a new authorized user/pharmacist/physicist to begin work under the license. In this case, the licensee is only required to notify the Agency within thirty days of the licensee approving an individual to act as an authorized user/pharmacist/physicist. The new authorized user/pharmacist/physicist will then be added to the license by the Agency during the next routine amendment (refer to G.10 and G.11.).

However, there are also many states that currently still require a new authorized user/pharmacist/physicist to be amended onto the license prior to assigning permanent authorized user/pharmacist/physicist status to the individual. These states still allow visiting authorized users/pharmacists/physicists. If you prefer to continue the visiting authorized user program, the following changes to Part G must be made:

Replace G.10b. with the following text:

> b. Before permitting anyone, except a visiting authorized user described in G.12, a visiting authorized medical physicist as described in G.13, or a visiting authorized nuclear pharmacist as described in G.14, to work as an authorized user, authorized medical physicist or authorized nuclear pharmacist under the license.

Amend G.11 to read as follows:

Sec. G.11 - Notifications.

a. A licensee shall notify the Agency by letter no later than 30 days after:

i. A Radiation Safety Officer permanently discontinues performance of duties under the license or has a name change;

ii. The licensee's mailing address changes;

iii. The licensee's name changes, but the name change does not constitute a transfer of control of the license as described in C.31b. of these regulations; or

iv. The licensee has added to or changed the areas where radioactive material is used in accordance with G.44 and G.47.

Add sections G.12, G.13, and G.14 as follows:

Sec. G.12 - Visiting Authorized User.

a. A licensee may permit a physician to act as a visiting authorized user and use licensed material for medical use under the terms of the licensee's license for 60 days each calendar year if:

i. The visiting authorized user has the prior written permission of the licensee's management and Radiation Safety Committee if one is required;

ii. The licensee has a copy of:

(1) An Agency, Agreement State, Licensing State or Nuclear Regulatory Commission license that identifies the visiting authorized user by name as an authorized user for medical use; or

(2) A permit issued by an Agency, NRC, Agreement State or Licensing State specific license of broad scope that identifies the authorized user by name as an authorized user for medical use; and,

iii. The visiting authorized user performs only those procedures:

(1) For which they are specifically authorized to perform on an Agency, Agreement State, Licensing State or Nuclear Regulatory Commission license; and,

(2) Which are specifically approved on the licensee's license.

b. A licensee need not apply for a license amendment in order to permit a visiting authorized user to use licensed material as described in G.12a.

c. A licensee shall retain copies of the records specified in G.12a. [for 3 years from the date of the last visit].

Sec. G.13 - Visiting Authorized Medical Physicist.

a. A licensee may permit a medical physicist to act as a visiting authorized medical physicist, and perform the duties of a medical physicist under the terms of the licensee's license for 60 days each calendar year if:

i. The visiting authorized medical physicist has the prior written permission of the licensee's management and Radiation Safety Committee, if one is required; and

ii. The licensee has a copy of:

(1) An Agency, Agreement State, Licensing State or Nuclear Regulatory Commission license that identifies the individual as an authorized medical physicist; or

(2) A permit issued by an Agency, NRC, Agreement State or Licensing State specific license of broad scope that identifies the medical physicist by name as an authorized medical physicist.

b. A licensee need not apply for a license amendment in order to permit a visiting authorized medical physicist to perform licensed duties as described in G.13a.

c. A licensee shall retain copies of the records specified in G.13a. [for 3 years from the date of the last visit].

Sec. G.14 - Visiting Authorized Nuclear Pharmacist.

a. A licensee may permit a nuclear pharmacist to act as a visiting authorized nuclear pharmacist, and to perform the duties of a nuclear pharmacist under the terms of the licensee's license for 60 days each calendar year if:

i. The visiting authorized nuclear pharmacist has the prior written permission of the licensee's management and Radiation Safety Committee, if one is required; and

ii. The licensee has a copy of:

(1) An Agency, Agreement State, Licensing State or Nuclear Regulatory Commission license that identifies the individual as an authorized nuclear pharmacist; or

(2) A permit issued by an Agency, NRC, Agreement State or Licensing State specific license of broad scope that identifies the nuclear pharmacist by name as an authorized nuclear pharmacist.

b. A licensee need not apply for a license amendment in order to permit a visiting authorized nuclear pharmacist to perform licensed duties as described in G.14a.

c. A licensee shall retain copies of the records specified in G.14a. [for 3 years from the date of the last visit].

Add the following rule section to G.18a.:

iv. Any individual before allowing that individual to work as a visiting authorized user, visiting authorized nuclear pharmacist or visiting authorized medical physicist.

A public meeting on the revision of Part 35 was held between the NRC and the Organization of Agreement States. During this meeting, many individuals commented that the specific duties of the authorized user should be detailed in the rules. The committee agrees, and has responded by including rule text that specifies the duties of an authorized user and authorized medical physicist (G.20). The committee also considered alternative text for G.20, but decided that a single option in the actual rule text was less confusing. However, to allow maximum flexibility, alternative G.20a. text is as follows:

Sec. G.20 - Duties of Authorized User and Authorized Medical Physicist.

a. A licensee shall assure that only authorized users of radioactive material:

i. Select the patients to receive radioactive material or radiation from radioactive material;

ii. Prescribe the radiopharmaceutical dosage and/or dose to be administered through the issuance of a written directive or reference to the diagnostic clinical procedures manual; and

iii. Interpret the results of tests, studies, or treatments.

The committee has continued to include rule text regarding the availability of an authorized user to communicate with a supervised individual (G.21c.). The NRC does not include this text in their rule. The committee believes that communication is key to supervision, and has left this section in the revised rule as recommended, optional, bracketed text.

We have included a set of minimum training and experience criteria for nuclear medicine technologists and radiation therapists (G.28), and required training records retention (G.101). Many states already have registration, licensing or other training requirements for nuclear medicine technologists and radiation therapists. However other states have requested that the committee include some sort of minimum technologist training and experience. The training and experience requirements only refer to radiation safety training, and meeting them cannot be construed as being adequate to assure that the technologist is competent in their field. These rules are not a matter of compatibility, but are offered as optional rule text.

We have included Sec. G.31 - Quality Control of Diagnostic Equipment. The NRC proposes to not address this subject, but rather allow QC requirements to be more performance based and goals

oriented. The committee recommends that this bracketed text be included in the rule for imaging equipment such as gamma cameras. This serves to remind the licensee of their QC requirements.

We have specified the minimum quality control tests required for the licensee to perform on instruments used to measure the activity of unsealed sources in G.32c. This bracketed, optional text makes the rule more specific and less performance based. It is not required to maintain compatibility, however it makes it clear to the licensee what minimum QC the Agency will accept.

We have added bracketed text in G.33d. requiring daily checks of survey meter consistency of response. This is a reinforcement of Part D requirements that surveys be performed with an "operable" survey meter. This text is not required to maintain compatibility.

In G.34 the NRC is relying on the "standards of care" to assure that the dose is calibrated within a reasonable time before administration. The committee recommends the bracketed text in G.34a. be adopted as the minimum requirement to lessen the possibility of misadministrations and to enhance ALARA.

The committee included previous rule text in the bracketed G.38, "Vial Shields". The NRC has deleted this clarifying text from the revised rule. They have decided to let Part 20 stand alone on this subject without additional reminders to the licensee. This text is not required for compatibility purposes, however the committee believes that it reinforces the Part D ALARA requirement and recommends that it be included.

For "Surveys for Ambient Radiation Dose Rate and Contamination"(G.39), the NRC only requires surveys in areas where radiopharmaceuticals that require a written directive are prepared and used. They are relying on Part 20 requirements to assure that "appropriate" surveys are performed. Since appropriate is not defined, and would require the inspector to make judgment calls at each inspection, the committee prefers setting the minimum acceptable criteria in the rules. We have added, and recommend the inclusion of, the bracketed text of paragraphs G.39b. through G.39g.

In G.42, "Storage and Control of Volatiles and Gases", the NRC is allowing Part 20 to stand alone and has deleted this rule. The committee believes this type of reminder in the rules is helpful to the licensee and ALARA, and recommends it be included.

The NRC has dropped the text of G.45, "Possession of Survey Instrument", and is relying on Part 20 requirements to assure that the licensee has proper survey capabilities. Although this text is not required for compatibility, the committee recommends adoption of it as reinforcement of Part D requirements.

In G.48, "Radionuclide Contaminants", the committee has added requirements to the rules pertaining to the possible break through of strontium-82, and strontium-85 because of the increase in use of strontium-82/rubidium-82 generators.

The NRC has deleted the rule text found in Sec. G.50 - Possession of Survey Instruments, and is relying on Part 20 requirements to assure that the licensee has proper survey capabilities. Although this text is not required for compatibility, the committee recommends adoption of it as reinforcement of Part D requirements.

Throughout these rules, we have included Licensing State as a legal entity along with Agreement States and the U.S. Nuclear Regulatory Commission whenever possible. However, whenever a rule section has been assigned a compatibility category B or C, we have not included Licensing State to assure that the section is compatible with NRC rules. An Agency may wish to include Licensing States, but should first check with the NRC regarding compatibility.

II. Other Corresponding Rule Changes

If Part G is adopted, there are some corresponding changes to other Parts that should be made. Below are the changes that would be required. Where appropriate, new or additional text has been underlined.

Part A should have the definition of "Sealed Source and Device Registry" added to it.

Sec. C.28j. - Manufacture and Distribution of Radiopharmaceuticals Containing Radioactive Material for Medical Use Under Group Licenses.

Sec. C.28j. and C.28j.iv.(1) - Change references from G.30, G.32 and G.36 to G.44, G.47 and G.52.

Sec. C.28k. - Manufacture and Distribution of Generators or Reagent Kits for Preparation of Radiopharmaceuticals Containing Radioactive Material. Change reference from G.32 to G.47 and G.52.

Sec. C28k.v.(2) - Change reference from G.32 to G.47 and G.52.

C.28l. - Manufacture and Distribution of Sources or Devices Containing Radioactive Material for Medical Use. Change references from G.40 and G.42 to G.59 and G.69.

Sec. C.28l.iii. - Change references from G.40 and G.42 to G.59 and G.69.

Sec. D.301 - Dose Limits for Individual Members of the Public.

a. Each licensee or registrant shall conduct operations so that:

   i. Except as provided in D.301a.iii., the total effective dose equivalent to individual members of the public from the licensed or registered operation does not exceed 1 millisievert (0.1 rem) in a year, exclusive of the dose contributions from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with G.40 of these regulations, from voluntary participation in medical research programs, and from the licensee's or registrant's disposal of radioactive material into sanitary sewerage in accordance with D.1003; and

   ii. The dose in any unrestricted area from external sources does not exceed 0.02 millisievert (0.002 rem) in any one hour; and

   iii. The total effective dose equivalent to individual members of the public from infrequent exposure to radiation from radiation machines does not exceed 5 millisievert (0.5 rem).

iv. Notwithstanding D.301a.i., a licensee may permit visitors to individuals who are not released in accordance with G.40 of these regulations to receive a radiation dose greater than 1 millisievert (0.1 rem) if:

(1) The radiation dose received does not exceed 5 millisievert (0.5 rem); and,

(2) The authorized user, as defined in Part G of these regulations, determines, before the visit, that it is appropriate.

III. Compatibility Issues

As stated in the NRC's Statements of Consideration, sections of 10 CFR Part 35 will be a matter of compatibility. There are no compatibility category A designations in the revised Part 35. The following is a list of sections (as found in the revised Part G) that have been designated a compatibility category B , C or H&S:

Rule Section	Compatibility Designation
G.2 - Definitions:	
Agreement State	B
Authorized medical physicist	B
Authorized nuclear pharmacist	B
Authorized user	B
Medical use	C
Prescribed dosage	C
Prescribed dose	C
Radiation safety officer	B
Sealed source	B
Treatment site	C
G.4 - Provisions for research involving human subjects	C
G.7 - License required	C
G.9 - Mobile medical service administrative requirements	
Paragraph c.	H&S
G.18 - Authority and responsibilities for the radiation protection program	
Paragraph b.	H&S
Paragraph f.	H&S
G.21 - Supervision	H&S
G.22 - Written directives	
Paragraph a.	H&S
Paragraph b.	H&S
G.23 - Procedures for administrations requiring a written directive	
Paragraph a.	H&S
G.24 - Suppliers for sealed sources or devices for medical use	C
G.25 - Training for radiation safety officer	B
G.26 - Training for authorized medical physicist	B
G.27 - Training for authorized nuclear pharmacist	B
G.29 - Provisions for experienced radiation safety officer, medical physicist, authorized user and nuclear pharmacist	B

G.30 - Recentness of training	B
G.32 - Possession, use, and testing of instruments to measure the activity of unsealed radioactive materials	
Paragraph a.	H&S
Paragraph b.	H&S
G.33 - Calibration of survey instruments	
Paragraph a.	H&S
Paragraph b.(except iii)	H&S
Paragraph c.	H&S
G.34 - Determination of dosages of radioactive material for medical use	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
G.36 - Requirements for possession of sealed sources and brachytherapy sources	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
G.37 - Labels	H&S
G.39 - Surveys of ambient radiation dose rate and contamination	
Paragraph a.	H&S
G.40 - Release of individuals containing radioactive drugs or implants	
Paragraph a.	C
Paragraph b.	C
G.41 - Mobile medical service technical requirements	
Paragraph d.	H&S
Paragraph e.	H&S
G.43 - Decay-in-storage	H&S
G.44 - Use of unsealed radioactive material for uptake, dilution, or excretion studies for which a written directive is not required	H&S
G.46 - Training for uptake, dilution, and excretion studies	B
G.47 - Use of unsealed radioactive material for imaging and localization studies for which a written directive is not required	H&S
G.48 - Radionuclide contaminants	
Paragraph a.i.	H&S
Paragraph b.	H&S
G.51 - Training for imaging and localization studies	B
G.52 - Use of unsealed radioactive material for which a written directive is required	H&S
G.53 - Safety Instruction	
Paragraph a.	H&S
G.54 - Safety precautions	H&S
G.56 - Training for use of unsealed radioactive material for which a written directive is required	B
G.57 - Training for the oral administration of sodium iodide I-131 in quantities less than or equal to 1.22 gigabecquerels (33 millicuries) for which a written directive is required	B
G.58 - Training for the oral administration of sodium iodide I-131 in	

quantities greater than or equal to 1.22 gigabecquerels (33 millicuries) for which a written directive is required	B
G.59 - Use of sealed sources for manual brachytherapy	C
G.60 - Surveys after source implant and removal	
Paragraph a.	H&S
Paragraph b.	H&S
G.61 - Brachytherapy sources inventory	
Paragraph a.	H&S
Paragraph b.	H&S
G. 62 - Safety Instruction	
Paragraph a.	H&S
G.63 - Safety Precautions for patients or human research subjects receiving brachytherapy	H&S
G.64 - Calibration measurements of brachytherapy sealed sources	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph e.	H&S
G.65 - Therapy-related computer systems	H&S
G.67 - Training for use of manual brachytherapy sources	B
G.68 - Training for ophthalmic use of strontium-90	B
G.69 - Use of sealed sources for diagnosis	C
G.70 - Training for use of sealed sources for diagnosis	B
G.71 - Use of sealed sources in a remote afterloader unit, Teletherapy unit, or gamma stereotactic radiosurgery unit	C
G.72 - Surveys of patients and human research subjects treated with a remote afterloader unit	
Paragraph a.	H&S
G.73 - Installation, maintenance, adjustment, and repair	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
G.74 - Safety procedures and instructions for remote afterloader units, teletherapy units, and gamma stereotactic radiosurgery units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
G.75 - Safety precautions for remote afterloader units, teletherapy units, and gamma stereotactic radiosurgery units	H&S
G.76 - Dosimetry equipment	
Paragraph a.	H&S
Paragraph b.	H&S
G.77 - Full calibration measurements on teletherapy units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S

Paragraph e.	H&S
Paragraph f.	H&S
G.78 - Full calibration measurements on remote afterloader units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
Paragraph f.	H&S
Paragraph g.	H&S
Paragraph h.	H&S
G.79 - Full calibration measurements on gamma stereotactic radiosurgery units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
Paragraph f.	H&S
G.80 - Periodic spot-checks for teletherapy units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
G.81 - Periodic spot-checks for remote afterloader units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
G.82 - Periodic spot-checks for gamma stereotactic radiosurgery units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
Paragraph e.	H&S
Paragraph f.	H&S
G.83 - Additional technical requirements for mobile remote afterloader units	
Paragraph a.	H&S
Paragraph b.	H&S
Paragraph c.	H&S
Paragraph d.	H&S
G.84 - Radiation surveys	
Paragraph a.	H&S
Paragraph b.	H&S
G.85 - Five-year inspection for teletherapy and gamma stereotactic radiosurgery units	

Paragraph a.	H&S
Paragraph b.	H&S
G.86 - Therapy-related computer systems	H&S
G.88 - Training for use of remote afterloader units, teletherapy units, and gamma stereotactic radiosurgery units	B
G.119 - Report and notification of misadministrations	C
G.120 - Report and notification of a dose to an embryo/fetus or a nursing child	C
G.121 - Reports of leaking sources	C

Matters for Future Consideration

With the new, emerging technologies (such as the various intravascular brachytherapy types and the use of monoclonal antibodies), the committee must try to stay on top of regulatory issues that may arise as these uses become more common place.

As more and more states are adopting licensing or registration standards for diagnostic or therapeutic technologists, consideration should be given to working towards a consolidated standard that would assure techs who meet the requirements in one state, will be adequate in any other state in which they might work.

The committee should continue to fine tune requirements for mobile PET use.

Part G – Part 35 Cross-Reference Guide

Part G Section	Part 35 Section
G.1	35.1
G.2	35.2
G.3	35.5
G.4	35.6
G.5	35.7
G.6	35.10
G.7	35.11
G.8	35.12
G.9	35.80
G.10	35.13
G.11	35.14
G.15	35.15
G.16	35.18
G.17	35.19
G.18	35.24
G.19	35.26
G.20	NONE
G.21	35.27
G.22	35.40
G.23	35.41
G.24	35.49
G.25	35.50
G.26	35.51
G.27	35.55
G.28	NONE
G.29	35.57
G.30	35.59
G.31	NONE
G.32	35.60
G.33	35.61
G.34	35.63
G.35	35.65
G.36	35.67
G.37	35.69
G.38	NONE
G.39	35.70
G.40	35.75
G.41	35.80
G.42	NONE
G.43	35.92
G.44	35.100
G.45	NONE
G.46	35.190
G.47	35.200

G.48	35.204
G.49	Reserved
G.50	NONE
G.51	35.290
G.52	35.300
G.53	35.310
G.54	35.315
G.55	NONE
G.56	35.390
G.57	35.392
G.58	35.394
G.59	35.400
G.60	35.404
G.61	35.406
G.62	35.410
G.63	35.415
G.64	35.432 and 35.433
G.65	35.457
G.66	NONE
G.67	35.490
G.68	35.491
G.69	35.500
G.70	35.590
G.71	35.600
G.72	35.604
G.73	35.605
G.74	35.610
G.75	35.615
G.76	35.630
G.77	35.632
G.78	35.633
G.79	35.635
G.80	35.642
G.81	35.643
G.82	35.645
G.83	35.647
G.84	35.652
G.85	35.655
G.86	35.657
G.87	NONE
G.88	35.690
G.89	35.1000
G.90	35.2024
G.91	35.2026
G.92	35.2040
G.93	35.3045
G.94	35.3047
G.95	35.2060

G.96	35.2061
G.97	35.2063
G.98	35.2067
G.99	35.2070
G.100	35.2075
G.101	35.2080
G.102	35.2092
G.103	35.2204
G.104	NONE
G.105	35.2310
G.106	35.2404
G.107	35.2406
G.108	35.2432
G.109	35.2433
G.110	35.2605
G.111	35.2630
G.112	35.2632
G.113	35.2642
G.114	35.2643
G.115	35.2645
G.116	35.2647
G.117	35.2652
G.118	35.2655
G.119	35.3045
G.120	35.3047
G.121	35.3067
G.122	NONE
G.123	NONE

PART J

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Sec. J.1 - Purpose and Scope. This Part establishes requirements for notices, instructions and reports by licensees or registrants to individuals engaged in activities under a license or registration and options available to such individuals in connection with Agency inspections of licensees or registrants to ascertain compliance with the provisions of the Act and regulations, orders, and licenses issued thereunder regarding radiological working conditions. The regulations in this Part apply to all persons who receive, possess, use, own, or transfer sources of radiation registered with or licensed by the Agency pursuant to Parts B and C of these regulations.

General Regulatory Provisions and Specific Requirements

Sec. J.11 - Posting of Notices to Workers.

a. Each licensee or registrant shall post current copies of the following documents:

   i. The regulations in this Part and in Part D of these regulations;

   ii. The license, certificate of registration, conditions or documents incorporated into the license by reference and amendments thereto;

   iii. The operating procedures applicable to activities under the license or registration; and

   iv. Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Part A of these regulations, and any response from the licensee or registrant.

b. If posting of a document specified in J.11a.i., ii., or iii. is not practicable, the licensee or registrant may post a notice which describes the document and states where it may be examined.

c. Agency Form [X] "Notice to Employees" shall be posted by each licensee or registrant as required by these regulations.

d. Agency documents posted pursuant to J.11a.iv. shall be posted within 5 working days after receipt of the documents from the Agency; the licensee's or registrant's response, if any, shall be posted within five working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of five working days or until action correcting the violation has been completed, whichever is later.

e. Documents, notices, or forms posted pursuant to J.11 shall appear in a sufficient number of places to permit individuals engaged in work under the license or registration to observe them

on the way to or from any particular work location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

Sec. J.12 - Instructions to Workers.

a. All individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 1 millisievert (100 mrem):

i. Shall be kept informed of the storage, transfer, or use of sources of radiation in the licensee's or registrant's workplace;

ii. Shall be instructed in the health protection problems associated with exposure to radiation or radioactive material to the individual and potential offspring, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed;

iii. Shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of these regulations and licenses for the protection of personnel from exposures to radiation or radioactive material;

iv. Shall be instructed of their responsibility to report promptly to the licensee or registrant any condition which may constitute, lead to, or cause a violation of the Act, these regulations, or license condition, or any unnecessary exposure to radiation or radioactive material;

v. Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and

vi. Shall be advised as to the radiation exposure reports which workers shall be furnished pursuant to J.13.

b. In determining those individuals subject to the requirements of J.12a., licensees must take into consideration assigned activities during normal and abnormal situations involving exposure to radiation and/or radioactive material which can reasonably be expected to occur during the life of a licensed facility. The extent of these instructions shall be commensurate with potential radiological health protection problems present in the workplace.

Sec. J.13 - Notifications and Reports to Individuals.

a. Radiation exposure data for an individual and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in ~~J.13~~this section. The information reported shall include data and results obtained pursuant to these regulations, orders, or license conditions, as shown in records maintained by the licensee or registrant pursuant to D.~~1107~~2106 of these regulations. Each notification and report shall:

i. Be in writing;

ii. Include appropriate identifying data such as: the name of the licensee or registrant, the name of the individual, and the individual's ~~identification number, preferably~~ social security number;

iii. Include the individual's exposure information; and

iv. Contain the following statement:

"This report is furnished to you under the provisions of [cite appropriate Agency regulations] Part J. You should preserve this report for further reference."

b. Each licensee or registrant shall furnish to each worker annually a written report of the worker's dose as shown in records maintained by the licensee or registrant pursuant to D.~~1107~~ 2106 of these regulations.

c. Each licensee or registrant shall furnish a written report of the worker's exposure to sources of radiation at the request of a worker formerly engaged in activities controlled by the licensee or registrant. The report shall include the dose record for each year the worker was required to be monitored pursuant to D.1502~~502~~ of these regulations. Such report shall be furnished within 30 days from the date of the request, or within 30 days after the dose of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover the period of time that the worker's activities involved exposure to sources of radiation and shall include the dates and locations of work under the license or registration in which the worker participated during this period.

d. When a licensee or registrant is required pursuant to D.~~1202~~2202, D.~~1203~~2203, ~~or~~ D.~~1204~~ 2204, D.2205 ~~[~~or D.~~1206~~2206~~]~~ of these regulations to report to the Agency any exposure of an individual to sources of radiation, the licensee or the registrant shall also provide the individual a written report on the exposure data included therein. Such reports shall be transmitted at a time not later than the transmittal to the Agency.

e. At the request of a worker who is terminating employment with the licensee or registrant in work involving exposure to radiation or radioactive material, during the current year, each licensee or registrant shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

Sec. J.14 - Presence of Representatives of Licensees or Registrants and Workers During Inspection.

a. Each licensee or registrant shall afford to the Agency at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to these regulations.

b. During an inspection, Agency inspectors may consult privately with workers as specified in J.15. The licensee or registrant may accompany Agency inspectors during other phases of an inspection.

c. If, at the time of inspection, an individual has been authorized by the workers to represent them during Agency inspections, the licensee or registrant shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

d. Each ~~workers'~~worker's representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in J.12.

e. Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

f. With the approval of the licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers' representative, shall be afforded the opportunity to accompany Agency inspectors during the inspection of physical working conditions.

g. Notwithstanding the other provisions of J.14, Agency inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an Agency of the US Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.

Sec. J.15 - Consultation with Workers During Inspections.

a. Agency inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of these regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

b. During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which the worker has reason to believe may have contributed to or caused any violation of the Act, these regulations, or license condition, or any unnecessary exposure of an individual to sources of radiation under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of J.16a.

c. The provisions of J.15b. shall not be interpreted as authorization to disregard instructions pursuant to J.12.

Sec. J.16 - Requests by Workers for Inspections.

a. Any worker or representative of workers believing that a violation of the Act, these regulations, or license conditions exists or has occurred in work under a license or registration with regard to radiological working conditions in which the worker is engaged may request an inspection by giving notice of the alleged violation to the [Radiation Control Program]. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the [Radiation Control Program] no later than at the time of inspection except that, upon the request of the worker giving such notice, such worker's name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Agency, except for good cause shown.

b. If, upon receipt of such notice, the [Radiation Control Program] determines that the complaint meets the requirements set forth in J.16a., and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection shall be made as soon as practicable to determine if such alleged violation exists or has occurred. Inspections pursuant to J.16 need not be limited to matters referred to in the complaint.

c. No licensee, registrant, or contractor or subcontractor of a licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under these regulations or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of such worker or others of any option afforded by this Part.

Sec. J.17 - Inspections Not Warranted; Informal Review.

a. i. If the [Radiation Control Program] determines, with respect to a complaint under J.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, the [Radiation Control Program] shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the [cite appropriate State agency*/]. Such Agency will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee or registrant may submit an opposing written statement of position with the [cite appropriate State agency*/]. Such agency will provide the complainant with a copy of such statement by certified mail.

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*/ *The agency cited here should be the agency which, under State administrative procedures, has the power to review decisions made by the Radiation Control Program.*

ii. Upon the request of the complainant, the [cite appropriate State agency*/] may hold an informal conference in which the complainant and the licensee or registrant may orally present their views. An informal conference may also be held at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the [cite appropriate State agency*/] shall affirm, modify, or reverse the determination of the [Radiation Control Program] and furnish the complainant and the licensee or registrant a written notification of the decision and the reason therefor.

b. If the [Radiation Control Program] determines that an inspection is not warranted because the requirements of J.16a. have not been met, the complainant shall be notified in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of J.16a.

2002
RATIONALE FOR REVISIONS

PART J
NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Introduction

Part J of the *Suggested State Regulations for Control of Radiation* is based on 10 CFR Part 19, which is intended to provide options to workers concerning inspections of working conditions comparable to those provisions provided for inspections pursuant to the Occupational Safety and Health Act. The Nuclear Regulatory Commission continues to revise its standards for protection against ionizing radiation in 10 CFR Part 20. This revision incorporated updated scientific information and reflected changes in the basic philosophy of radiation protection councils for internal doses. Part 19 was revised to incorporate the necessary changes to accommodate the revisions to Part 20, thus necessitating associated changes to Part J.

Compatibility Requirements

The revision of Part 20, including corresponding changes to Part 19, was published in the Federal Register on July 13, 1995 (60 FR 36038) and became effective on August 15, 1995. The Nuclear Regulatory Commission considers the adoption of these regulations a matter of compatibility for all Agreement States.

See the July 13, 1995, Federal Register notice for further background information on specific changes to the revision to Part 19, which corresponds to the Part J revision. Other editorial changes consistent with the Conference of Radiation Control Program Directors, Inc., *Policies and Procedures for the Preparation and Publication of the Suggested State Regulations for Control of Radiation* will not specifically be noted in the rationale discussion for each section.

Specific Provisions

J.12a. and b. The Working Group revised these 2 sections to conform to the revision of Part 20.

J.12a, b, c & d. The Working Group made several reference changes to reflect the renumbering scheme in Part D.

Matters for Future Consideration

At this time there are no Matters for Future Consideration.