

7. REGULATIONS AND ADVISORIES

International and national regulations and guidelines pertinent to human exposure to plutonium and to other radioactive substances are summarized in Table 7-1. Recommendations for radiation protection for people in the general population as a result of exposure to radiation in the environment are found in the Federal Radiation Guidance (FRC 1960) and ICRP No. 26 (ICRP 1977). National guidelines for occupational radiation protection are found in the "Federal Radiation Protection Guidance for Occupational Exposure" (EPA 1987). This guidance for occupational exposure supersedes recommendations of the Federal Radiation Council for occupational exposure (FRC 1960). The new guidance presents general principles for the radiation protection of workers and specifies the numerical primary guides for limiting occupational exposure. These recommendations are consistent with the ICRP (ICRP 1977).

The basic philosophy of radiation protection is the concept of ALARA (As Low As Reasonably Achievable). As a rule, all exposure should be kept as low as reasonably achievable and the regulations and guidelines are meant to give an upper limit to exposure. Based on the primary guides (EPA 1987), guides for Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) have been calculated (ICRP 1977, 1979). The ALI is defined as "that activity of a radionuclide which, if inhaled or ingested by Reference Man (ICRP 1975), will result in a dose equal to the most limiting primary guide for committed dose" (EPA 1988a) (see Appendix B). The DAC is defined as "the concentration of radionuclide in air which, if breathed by Reference Man (ICRP 1975) for a work-year, would result in the intake of one ALI" (EPA 1988a). The ALIs and DACs refer to occupational situations but may be converted to apply to exposure of persons in the general population by application of conversion factors (Table 7-1).

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TABLE 7-1. Regulations and Guidelines Applicable to Plutonium and Plutonium Compounds

Agency	Description	Value*	References
<u>International</u>			
Guidelines:			
ICRP	Occupational - whole body exposure	5 rem/yr (50 mSv)	ICRP 1977
ICRP	Individual - short-term, to critical populations	0.5 rem/yr (5 mSv)	ICRP 1977
ICRP	Individual - chronic exposure	0.1 rem/yr (1 mSv)	ICRP 1977
<u>National</u>			
Regulations:			
a: Air:			
NRC	Cumulative annual dose limit for general population from nuclear power plant operations	0.5 rem/yr	NRC 1988 ^a 10 CFR 20.105(a)
NRC	Maximum concentration above background released at the boundary of power plant:		NRC 1988 ^a 10 CFR 20.106(a)
		<u>pCi/ml (Bq/ml)</u>	
	Plutonium-238 S	7×10^{-8} (3×10^{-9})	
	I	1×10^{-6} (4×10^{-8})	
	Plutonium-239 S	6×10^{-8} (2×10^{-9})	
	I	1×10^{-6} (4×10^{-8})	
	Plutonium-240 S	6×10^{-8} (2×10^{-9})	
	I	1×10^{-6} (4×10^{-8})	
	Plutonium-241 S	3×10^{-6} (1×10^{-7})	
	I	1×10^{-3} (4×10^{-5})	
	Plutonium-242 S	6×10^{-8} (2×10^{-9})	
	I	1×10^{-6} (4×10^{-8})	
	Plutonium-243 S	6×10^{-2} (2×10^{-3})	
	I	8×10^{-2} (3×10^{-3})	
	Plutonium-244 S	6×10^{-8} (2×10^{-9})	
	I	1×10^{-6} (4×10^{-8})	

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TABLE 7-1 (Continued)

Agency	Description	Value	References
NRC	Maximum concentration above background in restricted areas of:		NRC 1988 ^a 10 CFR 20.103(a)
		<u>pCi/ml (Bq/ml)</u>	
	Plutonium-238 S	2x10 ⁻⁶ (7x10 ⁻⁸)	
	I	3x10 ⁻⁵ (1x10 ⁻⁶)	
	Plutonium-239 S	2x10 ⁻⁶ (7x10 ⁻⁸)	
	I	4x10 ⁻⁵ (1x10 ⁻⁶)	
	Plutonium-240 S	2x10 ⁻⁶ (7x10 ⁻⁸)	
	I	4x10 ⁻⁵ (1x10 ⁻⁶)	
	Plutonium-241 S	9x10 ⁻⁵ (3x10 ⁻⁶)	
	I	4x10 ² (1x10 ¹)	
	Plutonium-242 S	2x10 ⁻⁶ (7x10 ⁻⁸)	
	I	4x10 ⁻⁵ (1x10 ⁻⁶)	
	Plutonium-243 S	2 (7x10 ⁻²)	
	I	2 (7x10 ⁻²)	
	Plutonium-244 S	2x10 ⁻⁶ (7x10 ⁻⁸)	
	I	3x10 ⁻⁵ (1x10 ⁻⁶)	
b. Water:			
EPA	MCL	<u>pCi/L (Bq/L)</u>	EPA 1988a
ODW	Gross alpha particle activity (excluding radon and uranium)	15 (6x10 ⁻¹)	40 CFR 141.15
NRC	Maximum concentration above background released at the boundary of power plant:		NRC 1988 ^a 10 CFR 20.106(a)
		<u>pCi/ml (Bq/ml)</u>	
	Plutonium-238 S	5 (0.2)	
	I	30 (1.1)	
	Plutonium-239 S	5 (0.2)	
	I	30 (1.1)	
	Plutonium-240 S	5 (0.2)	
	I	30 (1.1)	
	Plutonium-241 S	2x10 ² (7.4)	
	I	1x10 ³ (37.0)	
	Plutonium-242 S	5 (0.2)	
	I	30 (1.1)	
	Plutonium-243 S	3x10 ² (11.1)	
	I	3x10 ² (11.1)	
	Plutonium-244 S	4 (0.1)	
	I	10 (0.4)	

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TABLE 7-1 (Continued)

Agency	Description	Value	References
c. Nonspecific media:			
EPA	Reportable quantity	<u>Ci (Bq)</u>	EPA 1989
	Plutonium-234	1000 (3.7x10 ¹³)	
	Plutonium-235	1000 (3.7x10 ¹³)	
	Plutonium-236	0.1 (3.7x10 ⁹)	
	Plutonium-237	1000 (3.7x10 ¹³)	
	Plutonium-238	0.01 (3.7x10 ⁸)	
	Plutonium-239	0.01 (3.7x10 ⁸)	
	Plutonium-240	0.01 (3.7x10 ⁸)	
	Plutonium-241	1 (3.7x10 ⁸)	
	Plutonium-242	0.01 (3.7x10 ⁸)	
	Plutonium-243	1000 (3.7x10 ¹³)	
	Plutonium-244	0.01 (3.7x10 ⁸)	
	Plutonium-245	100 (3.7x10 ¹²)	
Guidelines:			
EPA	Occupational - the committed effective dose equivalent (internal) and annual effective dose equivalent (external) combined	5 rem/yr (50 mSv)	EPA 1987
FRC	Individual - whole body exposure	0.5 rem/yr (5 mSv)	FRC 1960 ^b
FRC	Individual - operational guide for "suitable sample of population" when individual whole body doses are not known	0.17 rem/yr (1.7 mSv)	FRC 1960 ^b
EPA	Occupational ALI for inhalation of class W forms of ^c :	<u>pCi (Bq)</u>	EPA 1988b
	Plutonium-234	2x10 ⁸ (8x10 ⁶)	
	Plutonium-235	3x10 ¹² (1x10 ¹¹)	
	Plutonium-236	2x10 ⁴ (7x10 ²)	
	Plutonium-237	3x10 ⁹ (1x10 ⁸)	
	Plutonium-238	7x10 ³ (3x10 ²)	
	Plutonium-239	6x10 ³ (2x10 ²)	
	Plutonium-240	6x10 ³ (2x10 ²)	
	Plutonium-241	3x10 ⁵ (1x10 ⁴)	

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TABLE 7-1 (Continued)

Agency	Description	Value	References
	Plutonium-242	7×10^3 (2×10^2)	
	Plutonium-243	4×10^{10} (1×10^9)	
	Plutonium-244	7×10^3 (3×10^2)	
	Plutonium-245	5×10^9 (2×10^8)	
	Plutonium-246	3×10^8 (9×10^6)	
EPA	Occupational ALI for inhalation of class Y forms of ^c :	EPA 1988b <u>pCi (Bq)</u>	
	Plutonium-234	2×10^8 (7×10^6)	
	Plutonium-235	3×10^{12} (9×10^{10})	
	Plutonium-236	4×10^4 (2×10^3)	
	Plutonium-237	3×10^9 (1×10^8)	
	Plutonium-238	2×10^4 (7×10^2)	
	Plutonium-239	2×10^4 (6×10^2)	
	Plutonium-240	2×10^4 (6×10^2)	
	Plutonium-241	8×10^5 (3×10^4)	
	Plutonium-242	2×10^4 (6×10^2)	
	Plutonium-243	4×10^{10} (1×10^9)	
	Plutonium-244	2×10^4 (7×10^2)	
	Plutonium-245	4×10^9 (2×10^8)	
	Plutonium-246	3×10^8 (1×10^7)	
EPA	Occupational ALI for ingestion of ^d :	EPA 1988b <u>pCi (Bq)</u>	
	Plutonium-234	8×10^9 (3×10^8)	
	Plutonium-235	9×10^{11} (3×10^{10})	
	Plutonium-236	2×10^6 (9×10^4)	
	Plutonium-237	1×10^{10} (5×10^8)	
	Plutonium-238	9×10^5 (3×10^4)	
	Plutonium-239	8×10^5 (3×10^4)	
	Plutonium-240	8×10^5 (3×10^4)	
	Plutonium-241	4×10^7 (1×10^6)	
	Plutonium-242	8×10^5 (3×10^4)	
	Plutonium-243	2×10^{10} (6×10^8)	
	Plutonium-244	8×10^5 (3×10^4)	
	Plutonium-245	2×10^9 (8×10^7)	
	Plutonium-246	4×10^8 (1×10^7)	
EPA	Occupational DAC for inhalation of class W forms of ^e :	EPA 1988b <u>pCi/cm³ (Bq/m³)</u>	
	Plutonium-234	9×10^{-2} (3×10^3)	
	Plutonium-235	1×10^3 (5×10^7)	
	Plutonium-236	8×10^{-6} (3×10^{-1})	
	Plutonium-237	1 (5×10^4)	
	Plutonium-238	3×10^{-6} (1×10^{-1})	
	Plutonium-239	3×10^{-6} (1×10^{-1})	

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TABLE 7-1 (Continued)

Agency	Description	Value	References
	Plutonium-240	3×10^{-6} (1×10^{-1})	
	Plutonium-241	1×10^{-4} (5)	
	Plutonium-242	3×10^{-6} (1×10^{-1})	
	Plutonium-243	2×10^1 (6×10^5)	
	Plutonium-244	3×10^{-6} (1×10^{-1})	
	Plutonium-245	2 (7×10^4)	
	Plutonium-246	1×10^{-1} (4×10^3)	
EPA	Occupational DAC for inhalation of class Y forms of ^e :	EPA 1988b <u>pCi/cm³ (Bq/m³)</u>	
	Plutonium-234	8×10^{-2} (3×10^3)	
	Plutonium-235	1×10^3 (4×10^7)	
	Plutonium-236	2×10^{-5} (7×10^{-1})	
	Plutonium-237	1 (5×10^4)	
	Plutonium-238	8×10^{-6} (3×10^{-1})	
	Plutonium-239	7×10^{-6} (3×10^{-1})	
	Plutonium-240	7×10^{-6} (3×10^{-1})	
	Plutonium-241	3×10^{-4} (1×10^1)	
	Plutonium-242	7×10^{-6} (3×10^{-1})	
	Plutonium-243	2×10^1 (6×10^5)	
	Plutonium-244	7×10^{-6} (3×10^{-1})	
	Plutonium-245	2 (6×10^4)	
	Plutonium-246	1×10^{-1} (4×10^3)	

*See Glossary and Appendix B for definitions of units.

ALI = Annual Limit of Intake

DAC = Derived Air Concentration

EPA = Environmental Protection Agency

FRC = Federal Radiation Council

I = Insoluble

ICRP = International Commission for Radiation Protection

MCL = Maximum Contaminant Level

mSv = millisievert

NRC = Nuclear Regulatory Commission

OCW = Office of Drinking Water

S = Soluble

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TABLE 7-1 (Continued)

Agency	Description	Value	References
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^aThe Nuclear Regulatory Commission limits in 10 CFR 20 are in the process of revision.

^bFRC guidance for occupational exposure is superseded by EPA (1987) Federal Radiation Protection Guidance.

^cConversion of the ALI for occupational settings to apply to exposure of persons in the general population is:

$$ALI_i = ALI * 0.1$$

where ALI_i is the intake for the general population, ALI is the intake for occupational exposures and 0.01 is the ratio of the dose limit to the individual (0.5 rem/yr) and the dose limit for occupational workers (5 rem/yr).

^dBased on a fractional uptake from the small intestine to blood (f_1) of 0.001.

^eConversion of the DAC for occupational exposure to apply to the general public is:

$$DAC_i = DAC * 0.03$$

where DAC_i refers to the "Derived Air Concentration" for exposure to the general population and 0.03 represents the adjustment for hours of exposure (168 hrs per month occupational vs. 720 hr per month of continuous exposure), breathing rate (29 m³/day for occupational vs. 22 m³/day for the general population) and dose limits (0.5 rem/yr for individuals vs. 5 rem/yr for occupational settings).

