

7. REGULATIONS AND ADVISORIES

International and national regulations and guidelines pertinent to human exposure to radium 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 supercedes 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 AURA (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 1987a), guides for Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) have been calculated (EPA 1988). 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 1988; ICRP 1979) (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 1988). 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 Radium

Agency	Description	Value ^{a*}	Reference
<u>International</u>			
Guidelines:			
ICRP	Occupational - whole body exposure	5 rem/yr (50 mSv/yr)	ICRP 1977
	Individual - short-term, to critical populations	0.5 rem/yr (5 mSv/yr)	
	Individual - chronic exposure	0.1 rem/yr (1 mSv/yr)	
WHO	Guideline values recommended	<u>pCi/L (Bq/L)</u>	WHO 1984
	Gross alpha activity	2.7 (0.1)	
	Gross beta activity	27 (1)	
<u>National</u>			
Regulations:			
a. Air:			
EPA OAQPS	Hazardous Air Pollutant NESHAPS (Radionuclides) (proposed)	NA	EPA 1989a
b. Water:			
EPA OWRS	Effluent limitations guidelines	NA	EPA 1982a 40 CFR 440
EPA ODW	MCL Radium-226, radium-228 Gross alpha particle activity (excluding radon and uranium)	<u>pCi/L (Bq/L)</u> 5 (2×10^{-1}) 15 (6×10^{-1})	EPA 1986c (40 CFR 141.15, 141.16)
c. Nonspecific media:			
EPA	Reportable quantity		EPA 1989b 40 CFR 302
		<u>Ci (Bq)</u>	
	Radium-223	1 (4×10^{10})	
	Radium-224	10 (4×10^{11})	
	Radium-225	1 (4×10^{10})	
	Radium-226	0.1 (4×10^9)	
	Radium-227	1000 (4×10^{13})	
	Radium-228	0.1 (4×10^9)	
EPA ORP	Radiation protection: Standards for nuclear power operations. Annual radiation dose equivalent to whole body	25 mrem	40 CFR 190.10
	Standards for management and disposal of spent fuel and wastes. Release limit, radium-226 ^b	100 Ci (4×10^{12} Bq)	40 CFR 191 Appendix A Table 1

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TABLE 7-1 (Continued)

Agency	Description	Value ^{a*}	Reference
	Standards for uranium and thorium mill tailings. Radium-226:		40 CFR
	First 15 cm of soil	$\frac{\text{pCi/g (Bq/g)}}{5 (2 \times 10^{-1})}$	192.12
	More than 15 cm below soil	$15 (6 \times 10^{-1})$	
	Groundwater protection	$\frac{\text{pCi/L (Bq/L)}}{5 (2 \times 10^{-1})}$	40 CFR
	Combined radium-226 and -228	$15 (6 \times 10^{-1})$	192.32
	Gross alpha particle activity (excluding radon and uranium)		
FDA	Levels in bottled water.	$\frac{\text{pCi/L (Bq/L)}}{5 (2 \times 10^{-1})}$	21 CFR
	Radium-226 and -228	$15 (6 \times 10^{-1})$	103.35
	Gross alpha particle activity		
NRC	Radiation standards for exposure levels, discharge, disposal	NA	NRC 1988 ^c
	Radium-226	0.01 μCi (4×10^2 Bq)	10 CFR 20 NRC 1988 ^c 10 CFR 20 Appendix C
Guidelines:			
EPA	Carcinogenic classification	Group A ^d	IRIS 1988, 1989
EPA	Occupational - the committed effective dose equivalent (internal) and annual effective dose equivalent (external) combined	5 rem/yr (50 mSv)	EPA 1987a
FRC	Individual - whole body exposure	0.5 rem/yr (5 mSv)	FRC 1960 ^e
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 ^e
EPA	Lung clearance class ^{f, g} : All forms	W	EPA 1988
EPA	Occupational ALI for inhalation of class W forms of ^h :		EPA 1988
	Radium-223	$\frac{\text{pCi (Bq)}}{7 \times 10^5 (3 \times 10^4)}$	
	Radium-224	$2 \times 10^6 (7 \times 10^4)$	
	Radium-225	$7 \times 10^5 (3 \times 10^4)$	
	Radium-226	$6 \times 10^5 (2 \times 10^4)$	
	Radium-227	$1 \times 10^{10} (4 \times 10^8)$	
	Radium-228	$1 \times 10^6 (4 \times 10^4)$	
EPA	Occupational ALI for ingestion of ^l :	$\frac{\text{pCi (Bq)}}{5 \times 10^6 (2 \times 10^5)}$	EPA 1988
	Radium-223	$8 \times 10^6 (3 \times 10^5)$	
	Radium-224	$8 \times 10^6 (3 \times 10^5)$	
	Radium-225	$2 \times 10^6 (7 \times 10^4)$	
	Radium-226	$2 \times 10^{10} (7 \times 10^8)$	
	Radium-227	$2 \times 10^6 (7 \times 10^4)$	
	Radium-228	$2 \times 10^6 (7 \times 10^4)$	

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TABLE 7-1 (Continued)

Agency	Description	Value ^{a*}	Reference
EPA	Occupational DAC for inhalation of class W forms of ^j :		EPA 1988
		pCi/cm ³ (Bq/m ³)	
	Radium-223	3x10 ⁻⁴ (1x10 ¹)	
	Radium-224	7x10 ⁻⁴ (3x10 ¹)	
	Radium-225	3x10 ⁻⁴ (1x10 ¹)	
	Radium-226	3x10 ⁻⁴ (1x10 ¹)	
	Radium-227	6 (2x10 ⁵)	
	Radium-228	5x10 ⁻⁴ (2x10 ¹)	

ALI = Annual Limit of Intake
 DAC = Derived Air Concentration
 EPA = Environmental Protection Agency
 FDA = Food and Drug Administration
 FRC = Federal Radiation Council
 ICRP = International Commission on Radiological Protection
 MCL = Maximum Contaminant Level
 NA = Not applicable
 NRC = Nuclear Regulatory Commission
 OAQPS = Office of Air Quality Planning and Standards
 ODW = Office of Drinking Water
 ORP = Office of Radiation Programs
 NESHAPS = National Emissions Standards for Hazardous Air Pollutants
 WHO = World Health Organization
 *See Glossary and Appendix B for definition of units

^aNumerical values are provided in this column, when available. However, many regulations list chemicals and/or involve requirements too complex for inclusion here. In these case, NA (Not Applicable) is inserted in this column. The cited references provide details of the regulations.

^bCumulative release to the accessible environment for 10,000 years after disposal per 1,000 metric tons of Heavy Metal or other units of waste.

^cThe Nuclear Regulatory Commission limits in 10 CFR 20 are in the process of revision.

^dGroup A: Human carcinogen.

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

^fLung clearance class indicates the rate at which the element is cleared from the lung: D (days), W (weeks), Y (years).

^gThe ALIs and DACs recommended by the EPA are numerically identical to those recommended by the ICRP Publication 30 (ICRP 1979).

^hConversion 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 0.1 is the ratio of the dose limit to the individual (0.5 rem/yr) and the dose limit for occupational workers (5 rem/yr).

ⁱBased on a fractional uptake from the small intestine to blood (f_1) of 0.2.

^jConversion 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 hrs 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).