

7. REGULATIONS AND ADVISORIES

International and national regulations and guidelines pertinent to human exposure to thorium and its radiations 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 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 (EPA 1988b). 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 1988b; 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 1988b). 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).

7. REGULATIONS AND ADVISORIES

TABLE 7-1. Regulations and Guidelines Applicable to Thorium

Agency	Description	Value*	Reference
<u>International</u>			
Guidelines:			
ICRP	Occupational - whole body exposure	5 rem/yr (50 mSv)	ICRP 1977
	Individual - short-term, to critical populations	0.5 rem/yr (5 mSv)	
	Individual - chronic exposure	0.1 rem/yr (1 mSv)	
<u>National</u>			
Regulations:			
a. Air:	Maximum permissible concentrations		NRC 1988 ^a
NRC		$\frac{\mu\text{Ci/mL}}{(\text{Bq/m}^3)}$	10 CFR 20
	228-thorium soluble:		
	40-hour week	9×10^{-12} (3×10^{-1})	
	168-hour week	3×10^{-13} (1×10^{-2})	
	228-thorium insoluble:		
	40-hour week	6×10^{-12} (2×10^{-1})	
	168-hour week	2×10^{-13} (7×10^{-3})	
	230-thorium soluble:		
	40-hour week	2×10^{-12} (7×10^{-2})	
	168-hour week	8×10^{-14} (3×10^{-3})	
	230-thorium insoluble:		
	40-hour week	1×10^{-11} (4×10^{-1})	
	168-hour week	3×10^{-13} (1×10^{-2})	
	232-thorium soluble:		
	40-hour week	3×10^{-11} (1)	
	168-hour week	1×10^{-12} (4×10^{-2})	
	232-thorium insoluble:		
	40-hour week	3×10^{-11} (1)	
	168-hour week	1×10^{-12} (4×10^{-2})	

7. REGULATIONS AND ADVISORIES

TABLE 7-1 (Continued)

Agency	Description	Value*	Reference
b. Water:			
NRC	Maximum permissible concentrations		NRC 1988 ^a
	228-thorium soluble:	$\mu\text{Ci/mL}$ (Bq/mL)	10 CFR 20
	40-hour week	2×10^{-4} (7×10^{-6})	
	168-hour week	7×10^{-6} (3×10^{-7})	
	228-thorium insoluble:		
	40-hour week	4×10^{-4} (1×10^{-5})	
	168-hour week	1×10^{-5} (4×10^{-7})	
	230-thorium soluble:		
	40-hour week	5×10^{-5} (2×10^{-6})	
	168-hour week	2×10^{-6} (8×10^{-8})	
	230-thorium insoluble:		
	40-hour week	9×10^{-4} (3×10^{-5})	
	168-hour week	3×10^{-5} (1×10^{-6})	
	232-thorium soluble:		
	40-hour week	5×10^{-5} (2×10^{-6})	
	168-hour week	2×10^{-6} (7×10^{-8})	
	232-thorium insoluble:		
	40-hour week	1×10^{-3} (4×10^{-5})	
	168-hour week	4×10^{-5} (1×10^{-6})	
EPA/ODW	Maximum contaminant level for gross alpha-particle radioactivity	15 pCi/L	EPA 1988c CFR 141.15
c. Nonspecific media:			
EPA	Reportable quantity	Ci (Bq)	EPA 1989b
	226-thorium	100 (4×10^{12})	40 CFR 302
	227-thorium	1 (4×10^{10})	
	228-thorium	0.01 (4×10^8)	
	229-thorium	0.001 (4×10^7)	
	230-thorium	0.01 (4×10^8)	
	231-thorium	100 (4×10^{12})	
	232-thorium	0.001 (4×10^7)	
	234-thorium	100 (4×10^{12})	
<u>Guidelines</u>			
EPA	Occupational - the committed effective dose equivalent (internal) and annual effective dose equivalent (external) combined	5 rem/yr (50 mSv)	EPA 1987

7. REGULATIONS AND ADVISORIES

TABLE 7-1 (Continued)

Agency	Description	Value*	Reference
FRC	Individual - whole body exposure	0.5 rem/yr (5 mSv)	FRC 1960 ^b
	Individual - operational guide for "suitable sample of population" when individual whole body doses are not known	0.17 rem/yr (1.7 mSv)	
EPA	Lung clearance class ^c : Oxides and hydroxides All others	Y W	EPA 1988b
EPA	Occupational ALI for inhalation of class W forms of ^e :	<u>pCi (Bq)</u> Thorium-226 2×10^8 (7×10^6) Thorium-227 3×10^5 (1×10^4) Thorium-228 1×10^4 (4×10^2) Thorium-229 9×10^2 (3×10^1) Thorium-230 6×10^3 (2×10^2) Thorium-231 6×10^9 (2×10^8) Thorium-232 1×10^3 (4×10^1) Thorium-234 2×10^8 (7×10^6)	EPA 1988b
EPA	Occupational ALI for inhalation of class Y forms of ^e :	<u>pCi (Bq)</u> Thorium-226 1×10^8 (4×10^6) Thorium-227 3×10^5 (1×10^4) Thorium-228 2×10^4 (7×10^2) Thorium-229 2×10^3 (7×10^1) Thorium-230 2×10^4 (7×10^2) Thorium-231 6×10^9 (2×10^8) Thorium-232 3×10^3 (1×10^2) Thorium-234 2×10^8 (7×10^6)	EPA 1988b

7. REGULATIONS AND ADVISORIES

TABLE 7-1 (Continued)

Agency	Description	Value*	Reference
EPA	Occupational ALI for ingestion of ^f :	pCi (Bq)	EPA 1988b
	Thorium-226	5×10^9 (2×10^8)	
	Thorium-227	1×10^8 (4×10^6)	
	Thorium-228	6×10^6 (2×10^5)	
	Thorium-229	6×10^5 (2×10^4)	
	Thorium-230	4×10^6 (1×10^5)	
	Thorium-231	4×10^9 (1×10^8)	
	Thorium-232	7×10^5 (3×10^4)	
Thorium-234	3×10^8 (1×10^7)		
EPA	Occupational DAC for inhalation of class W forms of ^g :	pCi/cm ³ (Bq/m ³)	EPA 1988b
	Thorium-226	6×10^{-2} (2×10^3)	
	Thorium-227	1×10^{-4} (4)	
	Thorium-228	4×10^{-6} (1×10^{-1})	
	Thorium-229	4×10^{-7} (1×10^{-2})	
	Thorium-230	3×10^{-6} (1×10^{-1})	
	Thorium-231	3 (1×10^5)	
	Thorium-232	5×10^{-7} (2×10^{-2})	
Thorium-234	8×10^{-2} (3×10^3)		
EPA	Occupational DAC for inhalation of class Y forms of ^g :	pCi/cm ³ (Bq/m ³)	EPA 1988b
	Thorium-226	6×10^{-2} (2×10^3)	
	Thorium-227	1×10^{-4} (4)	
	Thorium-228	7×10^{-6} (3×10^{-1})	
	Thorium-229	1×10^{-6} (4×10^{-2})	
	Thorium-230	6×10^{-6} (2×10^{-1})	
	Thorium-231	3 (1×10^5)	
	Thorium-232	1×10^{-6} (4×10^{-2})	
Thorium-234	6×10^{-2} (2×10^3)		

^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.

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

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

7. REGULATIONS AND ADVISORIES

TABLE 7-1 (Continued)

Agency	Description	Value*	Reference
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^eConversion 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).

^fBased on a fractional uptake from the small intestine to blood (f_1) of 0.002.

^gConversion 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).

ALI = Annual Limit of Intake

DAC = Derived Air Concentration

EPA = Environmental Protection Agency

FRC = Federal Radiation Council

ICRP = International Commission on Radiological Protection

NRC = Nuclear Regulatory Commission

ODW = Office of Drinking Water

*See Glossary and Appendix B for definition of units.