

8. REGULATIONS AND ADVISORIES

International and national guidelines and state regulations regarding exposure to stable cobalt and its compounds are summarized in Table 8-1. The regulations regarding radioactive cobalt are summarized in Table 8-2.

Stable Cobalt. An MRL of 1×10^{-4} mg cobalt/m³ has been derived for chronic-duration inhalation exposure. The MRL is based on a NOAEL of 0.0053 mg cobalt/m³ for decreased respiratory function in exposed workers (Nemery et al. 1992). An MRL of 1×10^{-2} mg/kg-day has been derived for intermediate-duration oral exposure, based on a LOAEL of 1 mg/kg-day for polycythemia in human volunteers (Davis and Fields 1958). No other inhalation or oral MRLs were derived.

The EPA has not derived an RfC or RfD for cobalt and compounds. Similarly, no cancer classification has been performed by the EPA (IRIS 2000). The American Conference of Governmental Industrial Hygienists (ACGIH) has given cobalt a classification of A3, *confirmed animal carcinogen with unknown relevance to humans*, and established an 8-hour time-weighted average (TWA) of 0.02 mg/m³ for occupational exposure (ACGIH 2000). The Occupational Safety and Health Administration (OSHA) has promulgated an 8-hour permissible exposure limit (PEL) of 0.1 mg/m³ (OSHA 2001e), and the National Institute for Occupational Safety and Health (NIOSH) recommends an 8-hour TWA of 0.05 mg/m³ (NIOSH 2001). IARC (2001b) reports that cobalt and cobalt compounds are *possibly carcinogenic to humans* (Group 2B), based on sufficient evidence for cobalt metal and cobalt oxides and limited evidence for cobalt chloride and cobalt sulfate.

Cobalt and its compounds are regulated by the Clean Water Effluent Guidelines for the following industrial point sources: nonferrous metal manufacturing, asbestos, timber products processing, paving and roofing, paint formulating, ink formulating, gum and wood, carbon black, and battery manufacturing (EPA 1988).

Radioactive Cobalt. No MRLs were derived for inhalation or oral exposure to radioactive cobalt. MRLs for acute and chronic exposure to ionizing radiation exist (Agency for Toxic Substances and Disease Registry 1999) and are applicable to cobalt. The EPA has not derived an RfC or RfD for radioactive

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Table 8-1. Regulations and Guidelines Applicable to Stable Cobalt

Agency	Description	Information	Reference
<u>INTERNATIONAL</u>			
Guidelines:			
IARC	Carcinogenicity classification Cobalt and cobalt compounds ^a	Group 2B ^b	IARC 2001b
<u>NATIONAL</u>			
Regulations and Guidelines:			
a. Air			
ACGIH	TLV-TWA Cobalt, elemental, and inorganic compounds (as Co)	0.02 mg/m ³	ACGIH 2000
NIOSH	REL (TWA) Cobalt metal, dust, and fumes (as Co)	0.05 mg/m ³	NIOSH 2001
	IDLH Cobalt metal, dust, and fumes (as Co)	20 mg/m ³	
OSHA	PEL (8-hour TWA) for general industry Cobalt metal, dust, and fumes (as Co)	0.1 mg/m ³	OSHA 2001e 29CFR1910.1000 Table Z
	PEL (8-hour TWA) for construction industry Cobalt metal, dust, and fumes (as Co)	0.1 mg/m ³	OSHA 2001d 29CFR1926.55
	PEL (8-hour TWA) for shipyard industry Cobalt metal, dust, and fumes (as Co)	0.1 mg/m ³	OSHA 2001c 29CFR1915.1000
USC	HAP (cobalt compounds)		USC 2001a 42USC7412
b. Water			
EPA	NPDES permit application testing requirements; conventional and nonconventional pollutants required to be tested by existing dischargers if expected to be present		EPA 2001g 40CFR122 Appendix D Table IV
	BPT effluent limitations		EPA 2001b 40CFR415.652
	Maximum for 1 day	3x10 ⁻⁴ kg/kkg	
	Average of daily values for 30 consecutive days	1.2x10 ⁻⁴ kg/kkg	
	Groundwater monitoring		EPA 2001d 40CFR264 Appendix IX
	Suggested method	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	

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Agency	Description	Information	Reference
<u>NATIONAL</u> (cont.)			
c. Food			
FDA	Drug products withdrawn or removed from the market for reasons of safety or effectiveness	All drug products containing cobalt salts (except radioactive forms of cobalt and its salts and cobalamin and its derivatives)	FDA 2000a 21CFR216.24
	New drug status accorded through rulemaking procedures	Cobalt preparations intended for use by man	FDA 2000b 21CFR310.502 (a)(7)
	Over-the-counter drugs; recommended warning and caution statement for cobalt as a cobalt salt	Required on articles containing ≥ 0.5 μg per dose and ≥ 2 μg per 24-hour period	FDA 2000e 21CFR369.20
	Substances generally recognized as safe; trace minerals added to animal feeds	Cobalt acetate Cobalt carbonate Cobalt chloride Cobalt oxide Cobalt sulfate	FDA 2000f 21CFR582.20
	Substances prohibited from use in human food	Cobaltous salts and its derivatives	FDA 2000g 21CFR189.120
d. Other			
ACGIH	Carcinogenicity classification Cobalt, elemental, and inorganic compounds (as Co)	A3 ^c	ACGIH 2000
	BEI		
	Cobalt in urine—end of shift at end of workweek Cobalt in blood—end of shift at end of workweek	15 $\mu\text{g}/\text{L}$ 1 $\mu\text{g}/\text{L}$	
EPA	Carcinogenicity classification RfC RfD	No data	IRIS 2000
	Toxic chemical release reporting; Community Right-to-Know; effective date	01/01/87	EPA 2001c 40CFR372.65(a)
	Hazardous waste; identification and listing	Contain ≤ 1 ppmv in synthesis gas fuel generated from hazardous waste	EPA 2001e 40CFR261.38 (b)(5)
	TSCA; health and safety data reporting		EPA 2001j 40CFR716.120
EPA	Municipal solid waste landfills; hazardous constituent for detection monitoring		EPA 2001f 40CFR258 Appendix I and II
	Suggested method	PQL	
	6010 7200 7201	70 $\mu\text{g}/\text{L}$ 500 $\mu\text{g}/\text{L}$ 10 $\mu\text{g}/\text{L}$	
	Reportable quantity (cobalt compounds)	1 pound	EPA 2001h 40CFR302.4

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Agency	Description	Information	Reference
<u>NATIONAL</u> (cont.)			
USC	Superfund imposition of tax on cobalt	\$4.45 per ton	USC 2001c 26USC4661
	Exemption of tax imposed on recycled cobalt		USC 2001b 26USC4662
<u>STATE</u>			
Regulations and Guidelines			
a. Air			
Alabama	HAP (cobalt compounds)		BNA 2001
Alaska	Air contaminant standard (TWA) Cobalt metal, dust, and fumes	0.05 mg/m ³	BNA 2001
California	Airborne contaminant (cobalt metal, dust, and fumes)		BNA 2001
	HAP (cobalt compounds)		BNA 2001
	Toxic air contaminant (cobalt compounds)		CA Air Resources Board 2000
Colorado	HAP (cobalt metal, dust, and fumes)		BNA 2001
	"High-concern" pollutant (cobalt and compounds)		BNA 2001
	Reportable pollutants (cobalt metal, dust, and fumes)		CO Dept. of Public Health and Environment 2000
Connecticut	HAP—hazard limiting value (cobalt metal, dust, and fumes)		BNA 2001
	8 hours	2 µg/m ³	
	30 minutes	10 µg/m ³	
Delaware	Reportable quantities		DE Air Quality Management 2000
	Cobalt carbonyl	1 pound	
	Cobaltous sulfamate	1,000 pounds	
	Cobalt, ((2,2'-(ethane-diylbis(nitrilomethylidyne)	1 pound	
Hawaii	Air contaminant limit (PEL-TWA) Cobalt metal, dust, and fumes	0.05 mg/m ³	BNA 2001
	HAP (cobalt compounds)		BNA 2001
Idaho	TAP non-carcinogenic increments		ID Dept. of Environmental Quality 2000
	Cobalt carbonyl and cobalt hydrocarbonyl (as Co)		
	OEL	1x10 ⁻¹ mg/m ³	
	EL	7x10 ⁻³ pounds/hour	
	AAC (24-hour average)	5x10 ⁻³ mg/m ³	
	Cobalt metal, dust, and fumes		
	OEL	5x10 ⁻² mg/m ³	
	EL	3.3x10 ⁻³ pounds/hour	
	AAC (24-hour average)	2.5x10 ⁻³ mg/m ³	
Illinois	Toxic air contaminant (cobalt)		IL EPA 2000a
Kansas	HAP (cobalt compounds)		KS Dept. of Health and Environment 2000

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Agency	Description	Information	Reference
STATE (cont.)			
Kentucky	HAP (cobalt compounds)		BNA 2001
Louisiana	Toxic air pollutant (cobalt compounds)		BNA 2001
Maine	Emissions standards	2,000 pounds	BNA 2001
Maryland	Toxic air pollutant (cobalt compounds)		BNA 2001
Michigan	High concern toxic air pollutants (cobalt compounds)		BNA 2001
Minnesota	HAP threshold (cobalt metal and cobalt carbonyl)	0.1 tons/year	BNA 2001
Missouri	HAP (cobalt compounds)		BNA 2001
Montana	Occupational air contaminant (cobalt metal, dust, and fumes)	0.1 mg/m ³	BNA 2001
Nebraska	HAP (cobalt compounds and cobalt)		BNA 2001
New Mexico	Toxic air pollutant (cobalt metal, dust, and fumes [as Co])		BNA 2001
	OEL	1x10 ⁻¹ mg/m ³	
	Emissions	6.67x10 ⁻³ pounds/hour	
New York	Annual guideline concentrations	5x10 ⁻³ µg/m ³	NYS Dept. of Environmental Conservation 2000
	Dangerous air contaminants (TLV) for cobalt metal, dust, and fumes	0.1 mg/m ³	BNA 2001
	HAP (cobalt compounds)		BNA 2001
	Transition limits (PEL)		BNA 2001
	Cobalt metal, dust, and fumes	0.1 mg/m ³	
	Final rule limits (TWA)		
	Cobalt metal, dust, and fumes	0.05 mg/m ³	
North Carolina	PEL-TWA (cobalt metal, dust, and fumes)	0.05 mg/m ³	BNA 2001
Ohio	TRI		Ohio EPA 2000
Oregon	Air contaminant (cobalt metal, dust, and fumes)	0.1 mg/m ³	BNA 2001
Rhode Island	HAP (cobalt compounds)		BNA 2001
South Carolina	Toxic air emissions (MAC) for cobalt compounds	0.25 µg/m ³	BNA 2001
Texas	HAP (cobalt metal, dust, and fumes)	0.1 mg/m ³	BNA 2001
Vermont	HAP (cobalt compounds)		BNA 2001
	Hazardous ambient air standards		BNA 2001
	Cobalt compounds		
	Annual average	0.12 µg/m ³	
	Averaging time	24 hours	
	Action level	6.2x10 ⁻³ pounds/8 hours	
Washington	Class B TAP and ASIL (24-hour average)		WA Dept. of Ecology 2000
	Cobalt metal, dust and fumes	0.17 µg/m ³	
	Cobalt carbonyl and cobalt hydrocarbonyl	0.33 µg/m ³	

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Agency	Description	Information	Reference
<u>STATE (cont.)</u>			
	Thresholds for HAPs		BNA 2001
	Cobalt carbonyl	0.1 tons/year	
	Cobalt metal, dust, and fumes	0.1 tons/year	
Wisconsin	HAP—existing sources		WI Dept. of Natural Resources 1999
	AAC <25 feet	4.08x10 ⁻³ pounds/hour	
	AAC ≥25 feet	1.704x10 ⁻² pounds/hour	
b. Water			
Alabama	Groundwater monitoring (cobalt)		BNA 2001
	Suggested methods	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	
Arizona	Drinking water guideline	0.70 µg/L	FSTRAC 1999
Arkansas	Groundwater monitoring (cobalt)		BNA 2001
	Suggested methods	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	
California	Chemicals known to cause cancer or reproductive toxicity; date of initial appearance on the list		Cal/EPA 2000
	Cobalt metal powder		
	Cobalt[II] oxide	07/01/92	
	Cobalt sulfate heptahydrate	07/01/92	
		06/02/00	
Colorado	Groundwater standard (cobalt)	0.05 mg/L	BNA 2001
Delaware	Groundwater monitoring (cobalt)		BNA 2001
	Suggested methods	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	
Illinois	Groundwater quality standards for Class II	1 mg/L	IL EPA 2000b
Kentucky	Hazardous waste constituent for groundwater monitoring (cobalt)		BNA 2001
Louisiana	Groundwater monitoring (cobalt)		BNA 2001
	Suggested methods	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	
Massachusetts	Groundwater monitoring (cobalt)		BNA 2001
	Suggested methods	PQL	
	6010	70 µg/L	
	7200	500 µg/L	
	7201	10 µg/L	
Minnesota	Drinking water guideline	2 µg/L	FSTRAC 1995
	Groundwater protection hazardous constituent for cobalt (total)		BNA 2001

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Agency	Description	Information	Reference
STATE (cont.)			
Missouri	Water quality standards Livestock, wildlife watering Groundwater	1×10^3 µg/L 1×10^3 µg/L	BNA 2001
New Mexico	Standards for groundwater of 10,000 mg/L TDS concentration or less (cobalt)	0.05 mg/L	BNA 2001
New York	Groundwater monitoring (cobalt) Suggested methods 6010 7200 7201	PQL 70 µg/L 500 µg/L 10 µg/L	BNA 2001
Tennessee	Effluent limitations—daily maximum concentration (cobalt)	10 mg/L	BNA 2001
Wisconsin	Drinking water guideline Groundwater standards (cobalt) Enforcement standard Preventive action limit	40 µg/L 40 µg/L 8 µg/L	FSTRAC 1999 BNA 2001
c. Food		No data	
d. Other			
Alabama	Detection limit values for comparable fuel specification for cobalt; concentration limit	4.6 mg/kg at 10,000 BTU/pound	BNA 2001
Arizona	Soil remediation levels (cobalt) Residential Non-residential	4.6×10^3 mg/kg 9.7×10^4 mg/kg	BNA 2001
Arkansas	Detection limit values for comparable fuel specification for cobalt; concentration limit Solid waste management (cobalt) Suggested methods 6010 7200 7201	4.6 mg/kg at 10,000 BTU/pound PQL 70 µg/L 500 µg/L 10 µg/L	BNA 2001 BNA 2001
California	Characteristics of toxicity for cobalt and cobalt compounds STLC TTLC Chemicals known to cause cancer or reproductive toxicity (cobalt metal powder); initial appearance on the list Hazardous substance (cobalt, cobalt carbonyl, and cobalt hydrocarbonyl)	80 mg/L 8,000 mg/kg (wet-weight) 07/01/92	BNA 2001 BNA 2001
Delaware	Detection limit values for comparable fuel specification for cobalt; concentration limit	4.6 mg/kg at 10,000 BTU/pound	BNA 2001
Florida	Toxic substance in the workplace (cobalt metal, dust, and fumes)		BNA 2001
Georgia	Soil concentration (cobalt)	20 mg/kg	BNA 2001

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Agency	Description	Information	Reference
STATE (cont.)			
Illinois	Analytical parameters and required quantitation limits for cobalt Water Soil Method	50 µg/L 10 mg/kg 6010A	BNA 2001
Indiana	Constituent subject to assessment monitoring (cobalt [total and dissolved])		BNA 2001
Maine	Screening standards for beneficial use (cobalt)	5,875 mg/kg (dry weight)	BNA 2001
Michigan	Identification and listing of hazardous waste (cobalt)	When in the form of 100 microns or less	BNA 2001
Minnesota	Hazardous substance Cobalt metal, dust, and fumes (as Co) Cobalt carbonyl (as Co) Cobalt, elemental and inorganic compounds (as Co) Cobalt hydrocarbonyl (as Co)		BNA 2001
Missouri	Hazardous constituent (cobalt [total])		BNA 2001
New Jersey	Hazardous substance Cobalt Cobalt carbonyl Cobalt compounds		BNA 2001
New York	Occupational lung disease; hard metal disease	Cobalt	BNA 2001
Ohio	Toxic release inventory		BNA 2001
Oklahoma	Fertilizer labels and labeling; minimum percentage accepted for registration (cobalt)	5×10^{-4} percent	BNA 2001

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Agency	Description	Information	Reference
Oregon	Toxic substance (cobalt)		BNA 2001
Pennsylvania	Hazardous substance (cobalt and cobalt fumes)		BNA 2001

^aCobalt compounds: includes cobalt(II) carbonate, cobalt(II) chloride, cobalt(II) nitrate, cobalt(II) oxide, cobalt(II,III) oxide, cobalt(III) oxide, and cobalt(II) sulfate

^bGroup 2B: possibly carcinogenic to humans

^cA3: confirmed animal carcinogen with unknown relevance to humans

AAC = acceptable ambient concentrations; ACGIH = American Conference of Governmental Industrial Hygienists; ASIL = acceptable source impact level; BEI = biological exposure indices; BNA = Bureau of National Affairs; BPT = best practicable control technology; BTU = British thermal unit; CFR = Code of Federal Regulations; EL = emissions levels; EPA = Environmental Protection Agency; FDA = Food and Drug Administration; FSTRAC = Federal-State Toxicology and Risk Analysis Committee; HAP = hazardous air pollutant; IARC = International Agency for Research on Cancer; IDLH = immediately dangerous to life and health; IRIS = Integrated Risk Information System; MAC = maximum allowable concentration; NIOSH = National Institute for Occupational Safety and Health; NPDES = National Pollutant Discharge Elimination System; OEL = occupational exposure limit; OSHA = Occupational Safety and Health Administration; PEL = permissible exposure limit; PQL = practical quantitation limit; REL = recommended exposure limit; RfC = reference concentration; RfD = reference dose; STLC = soluble threshold limit concentrations; TAP = toxic air pollutant; TDS = total dissolved solids; TLV = threshold limit value; TRI = Toxic Release Inventory; TSCA = Toxic Substances Control Act; TTLC = total threshold limit concentrations; TWA = time-weighted averages; USC = United States Code

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information	Reference
<u>INTERNATIONAL</u>			
Guidelines:			
IARC	Carcinogenicity classification	Group 1 (carcinogenic to humans)	IARC 2001b
ICRP	Occupational dose limits; effective dose	20 mSv per year, averaged over defined periods of 5 years	ICRP 1991
	Annual equivalent dose		
	Lens of the eye	150 mSv	
	Skin	500 mSv	
	Hands and feet	500 mSv	
ICRP	General population dose limits; effective dose	1 mSv in a year	ICRP 1991
	Annual equivalent dose		
	Lens of eye	15 mSv	
	Skin	50 mSv	
WHO	Drinking water quality	No data	
<u>NATIONAL</u>			
Regulations and Guidelines:			
a. Air			
ACGIH	All radiation exposures must be kept as low as reasonably achievable		ACGIH 2000
	Effective dose		ACGIH 2000
	Any single year	50 mSv	
	Averaged over 5 years	20 mSv per year	
	Annual equivalent dose		
	Lens of the eye	150 mSv	
	Skin	500 mSv	
	Hands and feet	500 mSv	
	Embryo-fetus exposures once the pregnancy is known		
	Monthly equivalent dose	0.5 mSv	
Dose to the surface of women's abdomen (lower trunk)	2 mSv for the remainder of the pregnancy		
Intake of radionuclide	1/20 of the ALI		

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information		Reference
NATIONAL (cont.)				
DOE	Radiation standards			DOE 2000 10CFR835 Appendix A
	Inhalation DAC ($\mu\text{Ci/mL}$)	Class Wa	Class Yb	
	^{55}Co	1×10^{-6}	1×10^{-6}	
	^{56}Co	1×10^{-7}	8×10^{-8}	
	^{57}Co	1×10^{-6}	3×10^{-7}	
	^{58}mCo	4×10^{-5}	3×10^{-5}	
	^{58}Co	5×10^{-7}	3×10^{-7}	
	^{60}mCo	2×10^{-3}	1×10^{-3}	
	^{60}Co	7×10^{-8}	1×10^{-8}	
	^{61}Co	3×10^{-5}	2×10^{-5}	
	^{62}mCo	7×10^{-5}	7×10^{-5}	
	Radiation standards for air immersion DACc ($\mu\text{Ci/mL}$) for ^{60}mCo	1×10^{-3}		DOE 2000 10CFR835 Appendix C
NIOSH	REL	No data		
USNRC	Effluent concentrations—air			USNRC 2001k 10CFR20 Appendix B Table 2
	^{55}Co	ALI ($\mu\text{Ci/mL}$)		
	Class Wd	4×10^{-9}		
	Class Ye	4×10^{-9}		
	^{56}Co			
	Class Wd	4×10^{-10}		
	Class Ye	3×10^{-10}		
	^{57}Co			
	Class Wd	4×10^{-9}		
	Class Ye	9×10^{-10}		
	^{58}Co			
	Class Wd	2×10^{-9}		
	Class Ye	1×10^{-9}		
	^{58}mCo			
	Class Wd	1×10^{-7}		
	Class Ye	9×10^{-8}		
	^{60}Co			
	Class Wd	2×10^{-10}		
	Class Ye	5×10^{-11}		
	^{60}mCo			
	Class Wd	6×10^{-6}		
Class Ye	4×10^{-6}			
^{61}Co				
Class Wd	9×10^{-8}			
Class Ye	8×10^{-8}			
^{62}mCo				
Class Wd	2×10^{-7}			
Class Ye	2×10^{-7}			

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information		Reference
NATIONAL (cont.)				
USNRC	Occupational values			USNRC 2001k 10CFR20 Appendix B Table 1
	Inhalation			
	⁵⁵ Co	ALI (μCi)	DAC (μCi/mL)	
	Class Wd	3x10 ³	1x10 ⁻⁶	
	Class Ye	3x10 ³	1x10 ⁻⁶	
	⁵⁶ Co			
	Class Wd	3x10 ²	1x10 ⁻⁷	
	Class Ye	2x10 ²	8x10 ⁻⁸	
	⁵⁷ Co			
	Class Wd	3x10 ³	1x10 ⁻⁶	
	Class Ye	7x10 ²	3x10 ⁻⁷	
	⁵⁸ Co			
	Class Wd	1x10 ³	5x10 ⁻⁷	
	Class Ye	7x10 ²	3x10 ⁻⁷	
	^{58m} Co			
	Class Wd	9x10 ⁴	4x10 ⁻⁵	
	Class Ye	6x10 ⁴	3x10 ⁻⁵	
	⁶⁰ Co			
	Class Wd	2x10 ²	7x10 ⁻⁸	
	Class Ye	3x10 ¹	1x10 ⁻⁸	
^{60m} Co				
Class Wd	4x10 ⁶	2x10 ⁻³		
Class Ye	3x10 ⁶	1x10 ⁻³		
⁶¹ Co				
Class Wd	6x10 ⁴	3x10 ⁻⁵		
Class Ye	6x10 ⁴	2x10 ⁻⁵		
^{62m} Co				
Class Wd	2x10 ⁵	7x10 ⁻⁵		
Class Ye	2x10 ⁵	6x10 ⁻⁵		
OSHA	Safety and health regulations for construction—ionizing radiation			OSHA 2001e 29CFR1926.53
	Toxic and hazardous substances—ionizing radiation			OSHA 2001d 29CFR1910.1096
b. Water				
EPA	Drinking water standards			EPA 2000
	Beta particle and photon activity (formerly man-made radionuclides)			
	MCL	4 mrem		
	Caner risk at 10 ⁻⁴	4 mrem/year		
	Gross alpha particle activity			
	MCL	15 pCi/L		
	Caner risk at 10 ⁻⁴	15 pCi/L		
Carcinogenic classification	Group A (human carcinogen)			

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Agency	Description	Information	Reference
NATIONAL (cont.)			
USNRC	Effluent concentrations		USNRC 2001k 10CFR20 Appendix B Table 2
	Water		
	⁵⁵ Co	ALI (μCi/mL)	
	Class Wd	2x10 ⁻⁵	
	⁵⁶ Co		
	Class Wd	6x10 ⁻⁶	
	⁵⁷ Co		
	Class Wd	6x10 ⁻⁵	
	⁵⁸ Co		
	Class Wd	2x10 ⁻⁵	
	⁵⁸ mCo		
	Class Wd	8x10 ⁻⁴	
	⁶⁰ Co		
	Class Wd	3x10 ⁻⁶	
	⁶⁰ mCo		
	Class Wd	2x10 ⁻²	
	⁶¹ Co		
	Class Wd	3x10 ⁻⁴	
	⁶² mCo		
	Class Wd	7x10 ⁻⁴	
	Releases to sewers—monthly average concentration		USNRC 2001k 10CFR20 Appendix B Table 3
	⁵⁵ Co	ALI (μCi/mL)	
	Class Wd	2x10 ⁻⁴	
	⁵⁶ Co		
	Class Wd	6x10 ⁻⁵	
	⁵⁷ Co		
	Class Wd	6x10 ⁻⁴	
⁵⁸ Co			
Class Wd	2x10 ⁻⁴		
⁵⁸ mCo			
Class Wd	8x10 ⁻³		
⁶⁰ Co			
Class Wd	3x10 ⁻⁵		
⁶⁰ mCo			
Class Wd	2x10 ⁻¹		
⁶¹ Co			
Class Wd	3x10 ⁻³		
⁶² mCo			
Class Wd	7x10 ⁻³		
c. Food and Drug			
FDA	Ionizing radiation for the treatment of poultry feed and poultry feed ingredients (energy sources)	Ionizing radiation is limited to gamma rays from sealed units of ⁶⁰ CO	FDA 1999 21CFR579.40
	Requirements regarding certain radioactive drugs for ⁵⁸ Co or ⁶⁰ Co	Labeled cyanocobalamin for use in intestinal absorption studies	FDA 2000d 21CFR310.503(c)

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information			Reference
NATIONAL (cont.)					
FDA	Sources of radiation used for inspection of food, packaged food, and controlling food processing				FDA 2000c 21CFR179.21 (a)(2)
d. Other					
DOE	Values for establishing sealed radioactive source accountability and radioactive material posting and labeling requirements	Activity (μCi)			DOE 2000 10CFR835 Appendix E
	^{56}Co	4.0×10^1			
	^{57}Co	2.3×10^2			
	^{58}Co	1.4×10^2			
	^{60}Co	1.8×10^1			
DOT	Activity values (Ci)	A1	A2		DOT 2001a 49CFR173.435 Table
	^{55}Co	13.5	13.5		
	^{56}Co	8.11	8.11		
	^{57}Co	216	216		
	^{58}mCo	1080	1080		
	^{58}Co	27.0	27.0		
	^{60}Co	10.8	10.8		
	Superfund, reportable quantity (Ci) (pounds)				DOT 2001b 49CFR172.101 Appendix A Table 2
	^{55}Co	10			
	^{56}Co	10			
	^{57}Co	100			
	^{58}Co	10			
	^{58}mCo	1,000			
	^{60}Co	10			
	^{60}mCo	1,000			
	^{61}Co	1,000			
	^{62}mCo	1,000			
EPA	Carcinogenicity classification	No data			IRIS 2000
	RfC				
	RfD				
	Annual possession quantities for environmental compliance (Ci/year)	Gas	Liquid/ Powder	Solid	EPA 2001a 40CFR61 Appendix E Table 1
	^{56}Co	2.3×10^{-6}	2.3×10^{-3}	2.3	
	^{57}Co	1.8×10^{-2}	1.8×10^1	1.8×10^4	
	^{58}Co	2.5×10^{-6}	2.5×10^{-3}	2.5	
	^{58}mCo	2.3×10^{-6}	2.3×10^{-3}	2.3	
	^{60}Co	4.6×10^{-2}	4.6×10^1	4.6×10^4	
	^{60}mCo	7.0	7.0×10^3	7.0×10^6	
	^{61}Co	9.8×10^{-1}	9.8×10^2	9.8×10^5	

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information	Reference
<u>NATIONAL (cont.)</u>			
EPA	Concentration levels for environmental compliance (Ci/m ³)		EPA 2001a 40CFR61 Appendix E Table 2
	⁵⁶ Co	1.8x10 ⁻¹³	
	⁵⁷ Co	1.3x10 ⁻¹²	
	⁵⁸ Co	6.7x10 ⁻¹³	
	^{58m} Co	1.2x10 ⁻¹⁰	
	⁶⁰ Co	1.7x10 ⁻¹⁴	
	^{60m} Co	4.3x10 ⁻⁹	
	⁶¹ Co	4.5x10 ⁻⁹	
	Carcinogenicity—slope factors		EPA 2002
	Lifetime risk per pCi— ingestion		EPA 2002
	Water		
	⁵⁷ Co	1.04x10 ⁻¹²	
	^{58m} Co	2.95x10 ⁻¹²	
	⁵⁸ Co	1.26x10 ⁻¹³	
	⁶⁰ Co	1.57x10 ⁻¹¹	
	Lifetime risk per pCi— ingestion		EPA 2002
	Food		
	⁵⁷ Co	1.49x10 ⁻¹²	
	^{58m} Co	4.18x10 ⁻¹²	
	⁵⁸ Co	1.83x10 ⁻¹³	
	⁶⁰ Co	2.23x10 ⁻¹¹	
	Lifetime risk per pCi— ingestion		EPA 2002
	Soil		
	⁵⁷ Co	2.78x10 ⁻¹²	
	^{58m} Co	7.44x10 ⁻¹²	
	⁵⁸ Co	3.47x10 ⁻¹³	
	⁶⁰ Co	4.03x10 ⁻¹¹	
	Lifetime risk per pCi— inhalation		EPA 2002
	⁵⁷ Co	2.09x10 ⁻¹²	
	^{58m} Co	5.99x10 ⁻¹²	
	⁵⁸ Co	6.88x10 ⁻¹⁴	
	⁶⁰ Co	3.58x10 ⁻¹¹	
	External exposure— risk/year per pCi/g soil		EPA 2002
	⁵⁷ Co	3.55x10 ⁻⁷	
	^{58m} Co	4.48x10 ⁻⁶	
	⁵⁸ Co	1.00x10 ⁻¹²	
	⁶⁰ Co	1.24x10 ⁻⁵	

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information		Reference
NATIONAL (cont.)				
EPA	Superfund, reportable quantities (Ci) (pounds)			EPA 2001i 40CFR302.4 Appendix B
	⁵⁵ Co	10		
	⁵⁶ Co	10		
	⁵⁷ Co	100		
	⁵⁸ mCo	1,000		
	⁵⁸ Co	10		
	⁶⁰ mCo	1,000		
	⁶⁰ Co	10		
	⁶¹ Co	1,000		
	⁶² mCo	1,000		
NCRP	Occupational exposures			NCRP1993
	Effective dose limits			
	Annual	50 mSv		
	Cummulative	10 mSv x age		
	Equivalent dose annual limits	150 mSv		
	Lens of eye	500 mSv		
	Skin, hands, and feet			
	Public exposures (annual)			
	Effective dose limits, continuous or frequent exposure	1 mSv		
	Effective dose limits, infrequent exposures	5 mSv		
Equivalent dose limits				
Lens of eye	15 mSv			
Skin, hands, and feet	50 mSv			
Embryo and fetus exposures (monthly)				
Effective dose limit	0.5 mSv			
USNRC	Activity values for radionuclides (Ci)	A1	A2	USNRC 2001a 10CFR71
	⁵⁵ Co	13.5	13.5	
	⁵⁶ Co	8.11	8.11	
	⁵⁷ Co	216	216	
	⁵⁸ mCo	1080	1080	
	⁵⁸ Co	27.0	27.0	
	⁶⁰ Co	10.8	10.8	
	Byproduct material listing; exempt concentrations			
	Liquid and solid concentration ($\mu\text{Ci}/\text{mL}^2$)			
	⁵⁷ C	5×10^{-3}		
⁵⁸ C	1×10^{-3}			
⁶⁰ C	5×10^{-4}			
			USNRC 2001e 10CFR30.70 Schedule A	

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information		Reference	
<u>NATIONAL (cont.)</u>					
USNRC	Byproduct material listing (μCi)			USNRC 2001b 10CFR30.71 Schedule B	
	^{58}mCo				
	^{58}Co	10			
		^{60}Co	10		
			1		
	Byproduct material listing (Ci)		Column If	Column IIg	USNRC 2001c 10CFR33.100 Schedule A
	^{58}mCo		100	1.0	
	^{58}Co		1.0	0.01	
		^{60}Co	0.1	1×10^{-4}	
	Items containing byproduct material listing— ^{60}Co (μCi)				USNRC 2001d 10CFR30.15(a)(8)
	Electron tubes		1.0		
	Spark gap irradiators		1.0		
	Medical use— ^{60}Co as a source for brachytherapy		As a sealed source in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer		USNRC 2001h 10CFR35.400
	Occupational values—oral ingestion				USNRC 2001k 10CFR20 Appendix B Table 1
	^{55}Co		ALI (μCi)		
	Class Wd		1×10^3		
	^{56}Co				
	Class Wd		5×10^2		
	Class Ye		4×10^2		
	^{57}Co				
	Class Wd		8×10^3		
	Class Ye		4×10^3		
	^{58}Co				
	Class Wd		2×10^3		
	Class Ye		1×10^3		
	^{58}mCo				
	Class Wd		6×10^4		
^{60}Co					
Class Wd		5×10^2			
Class Ye		2×10^2			
^{60}mCo					
Class Wd		1×10^6			
St. wall		1×10^6			
^{61}Co					
Class Wd		2×10^4			
Class Ye		2×10^4			
^{62}mCo					
Class Wd		5×10^4			
St. wall		4×10^4			

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information	Reference
<u>NATIONAL</u> (cont.)			
USNRC	Quantities of radioactive material requiring labeling (μCi)		USNRC 2001g 10CFR30 Appendix B
	^{58}mCo	10	
	^{58}Co	10	
	^{60}Co	1	
	Quantities of licensed material requiring labeling (μCi)		USNRC 2001i 10CFR20 Appendix C
	^{55}Co		
	^{56}Co	100	
	^{57}Co	10	
	^{58}mCo	100	
	^{58}Co	1,000	
	^{60}mCo	100	
	^{60}Co	1,000	
	^{61}Co	1	
	^{62}mCo	1,000	
		1,000	
	Quantities of radioactive materials requiring need for an emergency plan		USNRC 2001j 10CFR30.72 Schedule C
	Release fraction	0.001%	
	Quantity (Ci)	5,000	
	Radioactive waste classification		USNRC 2001i 10CFR61.55
	Class A (Ci/m ³)		
^{60}Co	≤ 700		
Reports of individual monitoring—processing or manufacturing for distribution, byproduct material in quantities exceeding ^{60}Co (Ci)			USNRC 2001f 10CFR20.2206 (a)(7)
	1.0		
<u>STATE</u>			
Regulations and Guidelines:			
a. Air			
Alabama	HAP—radionuclides		BNA 2001
California	HAP—radionuclides		BNA 2001
Hawaii	HAP—radionuclides		BNA 2001
Illinois	Toxic air contaminant—radionuclides		BNA 2001
Kansas	HAP—radionuclides		BNA 2001
Kentucky	HAP—radionuclides		BNA 2001
Minnesota	HAP—radionuclides		BNA 2001
Missouri	HAP—radionuclides		BNA 2001

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Table 8-2. Regulations and Guidelines Applicable to Radioactive Cobalt

Agency	Description	Information	Reference
<i>STATE (cont.)</i>			
Nebraska	HAP—radionuclides		BNA 2001
New York	HAP—radionuclides		BNA 2001
Rhode Island	HAP—radionuclides		BNA 2001
Wyoming	HAP—radionuclides		BNA 2001

^aClass W: refers to the approximate length of retention in the pulmonary region which is 10–100 days for this class

^bClass Y: refers to the approximate length of retention in the pulmonary region which is greater than 100 days for this class

^cAir immersion DAC values: based on a stochastic dose limit of 5 rems (0.05 Sv) per year or a nonstochastic (organ) dose limit of 50 rems (0.5 Sv) per year

^dClass W: all compounds except those given for Y

^eClass Y: oxides, hydroxides, halides, and nitrates

^fColumn I: gas concentration

^gColumn II: liquid and solid concentration

ACGIH = American Conference of Governmental Industrial Hygienists; ALI = annual limits on intake; BNA = Bureau of National Affairs; CFR = Code of Federal Regulations; DAC = derived air concentrations; DOE = Department of Energy; DOT = Department of Transportation; EPA = Environmental Protection Agency; FDA = Food and Drug Administration; IARC = International Agency for Research on Cancer; ICRP = International Commission on Radiological Protection; IRIS = Integrated Risk Information System; mSv = millisievert; NCRP = National Council on Radiation Protection; NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration; PEL = permissible exposure limit; REL = recommended exposure limit; RfC = reference concentration; RfD = reference dose; TLV = threshold limit value; TWA = time-weighted averages; USNRC = U.S. Nuclear Regulatory Commission; WHO = World Health Organization

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cobalt (IRIS 2000). Slope factors have been derived for exposure to cobalt radioisotopes (EPA 2002). The slope factors for ^{60}Co are 1.57×10^{-11} , 2.23×10^{-11} , and $4.03 \times 10^{-11}/\text{pCi}$ for ingestion of water, food, and soil, respectively. The slope factor for inhalation exposure is $3.58 \times 10^{-11}/\text{pCi}$, and $1.24 \times 10^{-5}/\text{year}/\text{pCi}/\text{g}$ soil for external exposure. The slope factors for ^{58}Co are 1.26×10^{-13} , 1.83×10^{-13} , and $3.47 \times 10^{-13}/\text{pCi}$ for ingestion of water, food, and soil, respectively. The slope factor for inhalation exposure is $6.88 \times 10^{-14}/\text{pCi}$ for inhalation exposure, and $1.00 \times 10^{-12}/\text{year}/\text{pCi}/\text{g}$ soil for external exposure. The slope factors for $^{58\text{m}}\text{Co}$ are 2.95×10^{-12} , 4.18×10^{-12} , and $7.44 \times 10^{-12}/\text{pCi}$ for ingestion of water, food, and soil, respectively. The slope factor for inhalation exposure is $5.99 \times 10^{-14}/\text{pCi}$ for inhalation exposure, and $4.48 \times 10^{-6}/\text{year}/\text{pCi}/\text{g}$ soil for external exposure. The slope factors for ^{57}Co are 1.04×10^{-12} , 1.49×10^{-12} , and $2.78 \times 10^{-12}/\text{pCi}$ for ingestion of water, food, and soil, respectively. The slope factor for inhalation exposure is $2.09 \times 10^{-12}/\text{pCi}$ for ingestion, and $3.55 \times 10^{-7}/\text{year}/\text{pCi}/\text{g}$ soil for external exposure.