

Table III-3. Comparison of Derived MCLs for Beta Particle and Photon Emitting Radionuclides (in pCi/L)

Nuclide (*half-life of 24 hours or less)	1976 limits based on critical organ at 4 mrem/yr	1976 Risks	1991 proposed limits at 4 ede mrem/yr	1991 risks	Comments (HB69 means National Bureau of Standards Handbook-69)	Corrected limits based on 4 mrem/yr critical	Risk at corrected limits
H-3 (HTO)	20,000	3.57e-05	60,900	1.09e-04			
Be-7	6,000	1.60e-05	43,500	1.16e-04			
C-11	NC		99,200	1.75e-04			
N-13			152,000				
C-14	2,000	1.09e-04	3,200	1.75e-04			
C-15			6,690,000				
O-15			495,000				
F-18 *	2,000	8.32e-06	39,500	1.64e-04			
Na-22	400	1.36e-04	466	1.59e-04			
Na-24			3,350	1.60e-04	Not in 1976, but in HB69	60	2.87e-06
Si-31 *	3,000	5.96e-05	10,200	2.02e-04			
P-33			1,870				
P-32	30	9.53e-06	641	2.04e-04			
S-35 (Inorg)	500	8.39e-06	12,900	2.16e-04			
Cl-36	700	7.86e-05	1,850	2.08e-04			
Cl-38 *	1,000	8.41e-06	21,200	1.78e-04			
K-42 *	900	4.08e-05	3,900	1.77e-04			
Ca-45	10	8.96e-07	1,730	1.55e-04			
Ca-47	80	1.80e-05	846	1.90e-04			
Sc-46	1,000	1.95e-05	863	1.68e-04	Error in 1976 Calculation	100	1.95e-05
Sc-47	300	2.97e-05	2,440	2.42e-04			
Sc-48	80	1.71e-05	766	1.64e-04			
V-48	90	2.16e-05	644	1.55e-04			
Cr-51	6,000	3.26e-05	38,000	2.06e-04			
Mn-52	90	1.77e-05	733	1.44e-04			
Mn-54	300	2.23e-05	2,010	1.50e-04			
Mn-56 *	300	9.64e-06	5,640	1.81e-04			
Fe-55	2,000	6.84e-05	9,250	3.17e-04			
Fe-59	200	5.14e-05	844	2.17e-04			
Co-57	1,000	3.21e-05	4,870	1.57e-04			
Co-58	9,000	8.80e-04	1,590	1.57e-04	MCL switched with Co-58m	300	2.96e-05
Co-58m	300	1.18e-06	64,900	2.56e-04	MCL switched with Co-58	9000	3.55e-05
Co-60	100	5.20e-05	218	1.13e-04			
Ni-59	300	2.52e-06	27,000	2.27e-04			

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Ni-63	50	1.02e-06	9,910	2.02e-04			
Ni-65 *	300	6.52e-06	8,810	1.92e-04			
Cu-64 *	900	1.70e-05	11,900	2.25e-04			
Zn-65	300	1.23e-04	396	1.62e-04			
Zn-69 *	6,000	1.62e-05	63,100	1.71e-04			
Zn-69m *	200	1.09e-05	4,220	2.30e-04			
Ga-67	NC		7,020	2.10e-04			
Ga-72 *	100	1.62e-05	1,190	1.93e-04			
Ge-71	6,000	1.13e-05	436,000	8.19e-04			
As-73	1,000	4.52e-05	7,850	3.55e-04			
As-74	100	1.97e-05	1,410	2.77e-04			
As-76	60	1.67e-05	1,060	2.95e-04			
As-77	200	1.44e-05	4,330	3.11e-04			
Se-75	900	2.65e-04	574	1.69e-04			
Br-82	100	5.86e-06	3,150	1.85e-04			
Rb-82			436,000				
Rb-86	600	2.06e-04	485	1.67e-04			
Rb-87	300	5.41e-05	501	9.04e-05			
Rb-88	NC		29,100	1.83e-04			
Rb-89	NC		52,700	1.81e-04			
Sr-82	NC		241	2.29e-04			
Sr-85	21,000	1.75e-03	2,830	2.36e-04	Wrong critical organ selected	900	7.49e-05
Sr-85m	900	5.66e-07	237,000	1.49e-04	Wrong critical organ selected	21000	1.32e-05
Sr-89	20	1.66e-06	599	2.38e-04			
Sr-90	8	2.03e-05	42	1.06e-04			
Sr-91 *	200	1.90e-05	2,160	2.05e-04			
Sr-92	200	1.31e-05	3,100	2.03e-04			
Y-90	60	3.06e-05	510	2.60e-04			
Y-91	90	4.07e-05	576	2.60e-04			
Y-91m *	9,000	1.07e-05	132,000	1.57e-04			
Y-92 *	200	1.48e-05	2,870	2.13e-04			
Y-93	90	1.85e-05	1,200	2.47e-04			
Zr-93	2,000	8.55e-05	5,090	2.17e-04			
Zr-95	200	2.68e-05	1,460	1.96e-04			
Zr-97 *	60	2.14e-05	650	2.32e-04			
Nb-93m	1,000	2.29e-05	10,500	2.40e-04			

Nuclide (*half-life of 24 hours or less)	1976 limits based on critical organ at 4 mrem/yr	1976 Risks	1991 proposed limits at 4 ede mrem/yr	1991 risks	Comments (HB69 means National Bureau of Standards Handbook- 69)	Corrected limits based on 4 mrem/yr critical	Risk at corrected limits
Nb-94	NC		707	1.63e-04			
Nb-95	300	2.16e-05	2,150	1.55e-04			
Nb-95m	NC		2,390	2.48e-04			
Nb-97 *	3,000	2.04e-05	23,500	1.60e-04			
Nb-97m			1,370,000				
Mo-99	600	3.54e-05	1,830	1.08e-04			
Tc-95	NC		69,700	1.22e-03			
Tc-95m	NC		3,120	1.75e-04			
Tc-96	300	3.17e-05	2,050	2.17e-04			
Tc-96m *	30,000	3.44e-05	176,000	2.02e-04			
Tc-97	6,000	4.82e-05	32,500	2.61e-04			
Tc-97m	1,000	6.94e-05	4,450	3.09e-04			
Tc-99	900	7.28e-05	3,790	3.07e-04			
Tc-99m	20,000	4.61e-05	89,600	2.07e-04			
Ru-97	1,000	1.86e-05	7,960	1.48e-04			
Ru-103	200	2.22e-05	1,810	2.01e-04			
Ru-105 *	NC		4,990	2.13e-04	Error in 1976, listed as Rh-105	300	1.28e-05
Rh-105m			5,551,000				
Ru-106	30	3.66e-05	203	2.48e-04			
Rh-103m *	30,000	1.03e-05	471,000	1.62e-04			
Rh-105 *	300	2.00e-05	3,720	2.48e-04	Error: should be listed as Ru-105		
Rh-106	NC		1,240,000	1.97e-04			
Pd-100	NC		1,300	1.53e-04			
Pd-101	NC		13,400	1.67e-04			
Pd-103	900	3.18e-05	6,940	2.45e-04			
Pd-107	NC		36,600	2.59e-04			
Pd-109	300	2.99e-05	2,120	2.12e-04			
Ag-105	300	1.63e-05	2,700	1.47e-04			
Ag-108			626,000				
Ag-108m	NC		723	1.94e-04			
Ag-109m			16,700,000				
Ag-110			1,840,000				
Ag-110m	90	2.86e-05	512	1.63e-04			
Ag-111	100	2.34e-05	1,080	2.53e-04			
Cd-109	600	9.81e-05	227	3.71e-05			
Cd-115	90	2.21e-05	958	2.35e-04			

Nuclide (*half-life of 24 hours or less)	1976 limits based on critical organ at 4 mrem/yr	1976 Risks	1991 proposed limits at 4 ede mrem/yr	1991 risks	Comments (HB69 means National Bureau of Standards Handbook- 69)	Corrected limits based on 4 mrem/yr critical	Risk at corrected limits
Cd-115m	90	4.46e-05	339	1.68e-04			
n-113m *	3,000	9.36e-06	52,400	1.63e-04			
n-114			976,000				
n-114m *	60	4.37e-05	323	2.35e-04			
n-115	300	4.46e-04	35	5.22e-05			
n-115m *	1,000	1.30e-05	16,400	2.14e-04			
Sn-113	300	3.72e-05	1,740	2.16e-04			
Sn-121	NC		6,060	2.58e-04			
Sn-121m	NC		2,260	1.53e-04			
Sn-125	60	3.41e-05	446	2.54e-04			
Sn-126	NC		293	2.19e-04			
Sb-122	90	2.72e-05	810	2.45e-04			
Sb-124	60	2.27e-05	563	2.13e-04			
Sb-125	300	4.12e-05	1,940	2.67e-04			
Sb-126	NC		544	1.77e-04			
Sb-126m	NC		58,500	1.61e-04			
Sb-127	NC		818	2.35e-04			
Sb-129	NC		3,090	1.99e-04			
Te-125m	600	6.15e-05	1,490	1.53e-04			
Te-127	900	2.62e-05	7,920	2.31e-04			
Te-127m	200	5.71e-05	663	1.89e-04			
Te-129	2,000	1.21e-05	27,200	1.65e-04			
Te-129m	90	4.07e-05	524	2.37e-04			
Te-131m	NC		26,800	4.58e-03			
Te-131	200	7.87e-07	971	3.82e-06			
Te-132	90	3.30e-05	580	2.13e-04			
-122			211,000				
-123	NC		10,700	2.13e-04			
-125			151	1.10e-04	Not in 1976 list, but in HB69		
-126	3	7.50e-06	81	2.02e-04			
-129	1	4.22e-06	21	8.87e-05			
-130	NC		1,190	2.17e-04			
-131	3	3.91e-06	108	1.41e-04			
-132 *	90	2.17e-06	8,190	1.98e-04			
-133 *	10	4.13e-06	549	2.27e-04			
-134 *	100	7.16e-07	21,400	1.53e-04			

Nuclide (*half-life of 24 hours or less)	1976 limits based on critical organ at 4 mrem/yr	1976 Risks	1991 proposed limits at 4 ede mrem/yr	1991 risks	Comments (HB69 means National Bureau of Standards Handbook- 69)	Corrected limits based on 4 mrem/yr critical	Risk at corrected limits
-135 *	30	2.62e-06	2,340	2.04e-04			
Cs-131	20,000	1.29e-04	22,800	1.47e-04			
Cs-134	20,000	3.22e-02	81	1.22e-04	Wrong critical organ selected	80	1.29e-04
Cs-134m *	80	1.41e-07	101,000	1.78e-04	Wrong critical organ selected	20,000	3.52e-05
Cs-135	900	1.48e-04	794	1.31e-04			
Cs-136	800	2.42e-04	518	1.57e-04			
Cs-137	200	2.14e-04	119	1.27e-04			
Cs-138	NC		25,600	1.75e-04			
Ba-131	600	3.57e-05	2,950	1.76e-04			
Ba-133			1,520				
Ba-133m			2,620				
Ba-137m			2,150,000				
Ba-139	NC		13,800	1.74e-04			
Ba-140	90	3.91e-05	582	2.53e-04			
La-140	60	1.89e-05	652	2.06e-04			
Ce-141	300	3.93e-05	1,890	2.48e-04			
Ce-143	100	2.02e-05	1,210	2.45e-04			
Ce-144	NC		261	2.60e-04	Not in 1976 list, but in HB69	30	3.22e-05
Pr-142 *	90	2.20e-05	1,040	2.54e-04			
Pr-143	100	2.23e-05	1,170	2.61e-04			
Pr-144	NC		47,000	1.67e-04			
Pr-144m			112,000				
Nd-147 *	NC		1,250	2.64e-04	Not in 1976 list	200	4.23e-05
Nd-149 *	900	1.51e-05	11,700	1.97e-04			
Pm-147	NC		5,240	2.71e-04	Not in 1976 list, but in HB69		
Pm-148	NC		605	2.95e-04			
Pm-148m	NC		575	1.34e-04			
Pm-149	100	1.88e-05	1,380	2.60e-04			
Sm-151	1,000	1.60e-05	14,100	2.26e-04			
Sm-153	200	2.74e-05	1,830	2.51e-04			
Eu-152 *	60	1.16e-05	841	1.62e-04	Reclassified as Eu-154m	200	1.84e-05
Eu-154	200	6.46e-05	573	1.85e-04	MCL switched with Eu-152	60	1.94e-05
Eu-155	600	3.27e-05	3,590	1.95e-04			
Eu-156	NC		600	2.17e-04			

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Gd-153	600	2.62e-05	4,680	2.04e-04			
Gd-159 *	200	1.82e-05	2,760	2.50e-04			
Tb-158	NC		1,250	1.81e-04			
Tb-160	100	2.50e-05	815	2.03e-04			
Dy-165 *	1,000	1.29e-05	15,100	1.95e-04			
Dy-166	100	3.14e-05	830	2.61e-04			
Ho-166	90	2.35e-05	981	2.56e-04			
Er-169	300	2.14e-05	3,640	2.60e-04			
Er-171 *	300	1.76e-05	3,800	2.23e-04			
Tm-170	100	2.53e-05	1,030	2.61e-04			
Tm-171	1,000	1.99e-05	12,700	2.52e-04			
Yb-169	NC		1,830	2.09e-04			
Yb-175	300	2.44e-05	3,110	2.53e-04			
Lu-177	300	2.99e-05	2,550	2.54e-04			
Hf-181	200	3.64e-05	1,170	2.13e-04			
Ta-182	100	2.29e-05	842	1.93e-04			
W-181	1,000	1.15e-05	19,000	2.18e-04			
W-185	300	2.50e-05	3,440	2.86e-04			
W-187 *	200	2.11e-05	2,660	2.80e-04			
Re-183	2,000		5,400		Unknown risk		
Re-186	300	4.69e-05	1,880	2.94e-04			
Re-187	9,000	4.83e-06	582,000	3.13e-04			
Re-188 *	200	2.56e-05	1,790	2.29e-04			
Os-185	200	1.15e-05	2,460	1.42e-04			
Os-191	600	6.19e-05	2,380	2.46e-04			
Os-191m *	9,000	1.57e-04	14,300	2.49e-04			
Os-193	200	3.00e-05	1,690	2.54e-04			
Ir-190	600	9.88e-05	1,010	1.66e-04			
Ir-192	100	2.12e-05	957	2.03e-04			
Ir-194 *	90	2.21e-05	1,040	2.56e-04			
Pt-191	300	1.51e-05	3,810	1.92e-04			
Pt-193	3,000	1.79e-05	46,100	2.75e-04			
Pt-193m	3,000	2.58e-04	3,020	2.59e-04			
Pt-197	300	2.23e-05	3,400	2.53e-04			
Pt-197m *	3,000	3.63e-05	17,500	2.12e-04			
Au-196	600		3,660		Unknown risk		
Au-198	100	1.79e-05	1,310	2.35e-04			

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Au-199	NC				Not in 1976 list, but in HB69	600	5.10e-05
Hg-197	NC		5,760	2.52e-04	Not in 1976 list, but in HB69	880	3.85e-05
Hg-197m	NC					600	5.51e-05
Hg-198							
Hg-203	NC		2,390	2.27e-03	Not in 1976 list, but in HB69	60	5.7e-04
Tl-200	NC				Not in 1976 list, but in HB69	1200	2.7e+00
Tl-201	NC				Not in 1976 list, but in HB69	880	1.11e-05
Tl-202	300	1.50e-05	3,840	1.92e-04			
Tl-204	300	5.43e-05	1,680	3.04e-04			
Tl-207			400,000				
Tl-208			283,000				
Tl-209			358,000				
Pb-203	1,000	3.04e-05	5,060	1.54e-04			
Pb-209	NC		25,300	1.88e-04			
Pb-210	NC		1	3.34e-05			
Pb-211	NC		12,800	2.03e-04			
Pb-212	NC		123	9.81e-05			
Pb-214	NC		11,800	1.52e-04			
Bi-206	100	2.29e-05	656	1.50e-04			
Bi-207	200	3.31e-05	1,010	1.67e-04			
Bi-212			5,200				
Bi-213	NC		15,000	2.79e-04			
Bi-214	NC		18,900	1.55e-04			
Fr-223	NC		3,410	8.51e-04			
Ra-225	NC		9	3.80e-05			
Ra-228			7.85				
Ac-227	NC		1	1.06e-05			
Ac-228	NC		3,270	1.92e-04			
Th-231	NC		4,070	2.55e-04			
Th-234	NC		401	2.62e-04			
Pa-233	300	4.73e-05	1,510	2.38e-04			
Pa-234	NC		2,560	1.94e-04			
Pa-234m			930,000				

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J-237	NC		1,780	2.46e-04			
J-240	NC		1,540	3.09e-04			
Np-236			5,960				
Np-238	NC		1,390	2.14e-04			
Np-239	NC		1,680	2.45e-04			
Np-240	NC		23,100	1.83e-04			
Np-240m			174,000				
Pu-241	NC		63	4.66e-06			
Pu-243	NC		16,400	2.27e-04			
Am-242m	NC		1	3.53e-06			
Bk-249					Not in 1976 list, but in HB69	1800	6.67e-05

Additional Notes:

1. 1976 values taken from Appendix B in EPA-570/9-76-003.
2. NC = not calculated.
3. 1991 values taken from Appendix B in 56 FR 33121.
4. Calculated using tap water mortality (fatal) and morbidity (total) risk coefficients from Table 2.2 of FGR-13, assuming lifetime daily intake of 2 liters of drinking water.

b. Alpha-Emitting Radionuclides

Both the current and 1991 proposed MCLs for alpha-emitting radionuclides permit up to 15 pCi/L of alpha particle radioactivity in drinking water from individual and multiple alpha emitters. EPA based the current gross alpha MCL of 15 pCi/L (including radium-226 and excluding radon and uranium) on a consideration of the risk posed by polonium-210, which the Agency believed was the most toxic alpha emitter likely to be found in drinking water besides radium-226. At that time, EPA thought that exposure to 10 pCi/L of polonium-210 posed a lifetime fatal cancer risk comparable to that from continuous lifetime ingestion of about 5 pCi/L of radium-226, that is, between 0.5 and 2×10^{-4} . In 1991, EPA based the revised, adjusted gross alpha MCL on revised dose and risk calculations which indicated that the 15 pCi/L limit posed a lifetime cancer risk for most alpha emitters that fell within EPA's acceptable risk range of between 10^{-6} and 10^{-4} .

Table III-4 compares the 15 pCi/L limit for individual alpha emitters with derived activity concentrations at the two reference risk levels — 5×10^{-5} lifetime fatal cancer risk and 1×10^{-4} lifetime total cancer risk.