

3701:1-38-18

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Appendix A**Quantities^a of Licensed Material Requiring Labeling**

Radionuclide (In Atomic Number Order)	Quantity (μ Ci) ^b	Radionuclide (In Atomic Number Order)	Quantity (μ Ci) ^b
Hydrogen-3	1,000	Scandium-49	1,000
Beryllium-7	1,000	Titanium-44	1
Beryllium-10	1	Titanium-45	1,000
Carbon-11	1,000	Vanadium-47	1,000
Carbon-14	100	Vanadium-48	100
Fluorine-18	1,000	Vanadium-49	1,000
Sodium-22	10	Chromium-48	1,000
Sodium-24	100	Chromium-49	1,000
Magnesium-28	100	Chromium-51	1,000
Aluminum-26	10	Manganese-51	1,000
Silicon-31	1,000	Manganese-52m	1,000
Silicon-32	1	Manganese-52	100
Phosphorus-32	10	Manganese-53	1,000
Phosphorus-33	100	Manganese-54	100
Sulfur-35	100	Manganese-56	1,000
Chlorine-36	10	Iron-52	100
Chlorine-38	1,000	Iron-55	100
Chlorine-39	1,000	Iron-59	10
Argon-39	1,000	Iron-60	1
Argon-41	1,000	Cobalt-55	100
Potassium-40	100	Cobalt-56	10
Potassium-42	1,000	Cobalt-57	100
Potassium-43	1,000	Cobalt-58m	1,000
Potassium-44	1,000	Cobalt-58	100
Potassium-45	1,000	Cobalt-60m	1,000
Calcium-41	100	Cobalt-60	1
Calcium-45	100	Cobalt-61	1,000
Calcium-47	100	Cobalt-62m	1,000
Scandium-43	1,000	Nickel-56	100
Scandium-44m	100	Nickel-57	100
Scandium-44	100	Nickel-59	100
Scandium-46	10	Nickel-63	100
Scandium-47	100	Nickel-65	1,000
Scandium-48	100	Nickel-66	10

^b To convert μ Ci to kBq, multiply the μ Ci value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Copper-60	1,000	Bromine-74	1,000
Copper-61	1,000	Bromine-75	1,000
Copper-64	1,000	Bromine-76	100
Copper-67	1,000	Bromine-77	1,000
Zinc-62	100	Bromine-80m	1,000
Zinc-63	1,000	Bromine-80	1,000
Zinc-65	10	Bromine-82	100
Zinc-69m	100	Bromine-83	1,000
Zinc-69	1,000	Bromine-84	1,000
Zinc-71m	1,000	Krypton-74	1,000
Zinc-72	100	Krypton-76	1,000
Gallium-65	1,000	Krypton-77	1,000
Gallium-66	100	Krypton-79	1,000
Gallium-67	1,000	Krypton-81	1,000
Gallium-68	1,000	Krypton-83m	1,000
Gallium-70	1,000	Krypton-85m	1,000
Gallium-72	100	Krypton-85	1,000
Gallium-73	1,000	Krypton-87	1,000
Germanium-66	1,000	Krypton-88	1,000
Germanium-67	1,000	Rubidium-79	1,000
Germanium-68	10	Rubidium-81m	1,000
Germanium-69	1,000	Rubidium-81	1,000
Germanium-71	1,000	Rubidium-82m	1,000
Germanium-75	1,000	Rubidium-83	100
Germanium-77	1,000	Rubidium-84	100
Germanium-78	1,000	Rubidium-86	100
Arsenic-69	1,000	Rubidium-87	100
Arsenic-70	1,000	Rubidium-88	1,000
Arsenic-71	100	Rubidium-89	1,000
Arsenic-72	100	Strontium-80	100
Arsenic-73	100	Strontium-81	1,000
Arsenic-74	100	Strontium-83	100
Arsenic-76	100	Strontium-85m	1,000
Arsenic-77	100	Strontium-85	100
Arsenic-78	1,000	Strontium-87m	1,000
Selenium-70	1,000	Strontium-89	10
Selenium-73m	1,000	Strontium-90	0.1
Selenium-73	100	Strontium-91	100
Selenium-75	100	Strontium-92	100
Selenium-79	100	Yttrium-86m	1,000
Selenium-81m	1,000	Yttrium-86	100
Selenium-81	1,000	Yttrium-87	100
Selenium-83	1,000	Yttrium-88	10
Bromine-74m	1,000	Yttrium-90m	1,000

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Yttrium-90	10	Ruthenium-103	100
Yttrium-91m	1,000	Ruthenium-105	1,000
Yttrium-91	10	Ruthenium-106	1
Yttrium-92	100	Rhodium-99m	1,000
Yttrium-93	100	Rhodium-99	100
Yttrium-94	1,000	Rhodium-100	100
Yttrium-95	1,000	Rhodium-101m	1,000
Zirconium-86	100	Rhodium-101	10
Zirconium-88	10	Rhodium-102m	10
Zirconium-89	100	Rhodium-102	10
Zirconium-93	1	Rhodium-103m	1,000
Zirconium-95	10	Rhodium-105	100
Zirconium-97	100	Rhodium-106m	1,000
Niobium-88	1,000	Rhodium-107	1,000
Niobium-89m (66 min)	1,000	Palladium-100	100
Niobium-89 (122 min)	1,000	Palladium-101	1,000
Niobium-90	100	Palladium-103	100
Niobium-93m	10	Palladium-107	10
Niobium-94	1	Palladium-109	100
Niobium-95m	100	Silver-102	1,000
Niobium-95	100	Silver-103	1,000
Niobium-96	100	Silver-104m	1,000
Niobium-97	1,000	Silver-104	1,000
Niobium-98	1,000	Silver-105	100
Molybdenum-90	100	Silver-106m	100
Molybdenum-93m	100	Silver-106	1,000
Molybdenum-93	10	Silver-108m	1
Molybdenum-99	100	Silver-110m	10
Molybdenum-101	1,000	Silver-111	100
Technetium-93m	1,000	Silver-112	100
Technetium-93	1,000	Silver-115	1,000
Technetium-94m	1,000	Cadmium-104	1,000
Technetium-94	1,000	Cadmium-107	1,000
Technetium-96m	1,000	Cadmium-109	1
Technetium-96	100	Cadmium-113m	0.1
Technetium-97m	100	Cadmium-113	100
Technetium-97	1,000	Cadmium-115m	10
Technetium-98	10	Cadmium-115	100
Technetium-99m	1,000	Cadmium-117m	1,000
Technetium-99	100	Cadmium-117	1,000
Technetium-101	1,000	Indium-109	1,000
Technetium-104	1,000	Indium-110 (69.1 min)	1,000
Ruthenium-94	1,000	Indium-110 (4.9 h)	1,000
Ruthenium-97	1,000	Indium-111	100

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Indium-112	1,000	Tellurium-121	100
Indium-113m	1,000	Tellurium-123m	10
Indium-114m	10	Tellurium-123	100
Indium-115m	1,000	Tellurium-125m	10
Indium-115	100	Tellurium-127m	10
Indium-116m	1,000	Tellurium-127	1,000
Indium-117m	1,000	Tellurium-129m	10
Indium-117	1,000	Tellurium-129	1,000
Indium-119m	1,000	Tellurium-131m	10
Tin-110	100	Tellurium-131	100
Tin-111	1,000	Tellurium-132	10
Tin-113	100	Tellurium-133m	100
Tin-117m	100	Tellurium-133	1,000
Tin-119m	100	Tellurium-134	1,000
Tin-121m	100	Iodine-120m	1,000
Tin-121	1,000	Iodine-120	100
Tin-123m	1,000	Iodine-121	1,000
Tin-123	10	Iodine-123	100
Tin-125	10	Iodine-124	10
Tin-126	10	Iodine-125	1
Tin-127	1,000	Iodine-126	1
Tin-128	1,000	Iodine-128	1,000
Antimony-115	1,000	Iodine-129	1
Antimony-116m	1,000	Iodine-130	10
Antimony-116	1,000	Iodine-131	1
Antimony-117	1,000	Iodine-132m	100
Antimony-118m	1,000	Iodine-132	100
Antimony-119	1,000	Iodine-133	10
Antimony-120 (16 min)	1,000	Iodine-134	1,000
Antimony-120 (5.76 d)	100	Iodine-135	100
Antimony-122	100	Xenon-120	1,000
Antimony-124m	1,000	Xenon-121	1,000
Antimony-124	10	Xenon-122	1,000
Antimony-125	100	Xenon-123	1,000
Antimony-126m	1,000	Xenon-125	1,000
Antimony-126	100	Xenon-127	1,000
Antimony-127	100	Xenon-129m	1,000
Antimony-128 (10.4 min)	1,000	Xenon-131m	1,000
Antimony-128 (9.01 h)	100	Xenon-133m	1,000
Antimony-129	100	Xenon-133	1,000
Antimony-130	1,000	Xenon-135m	1,000
Antimony-131	1,000	Xenon-135	1,000
Tellurium-116	1,000	Xenon-138	1,000
Tellurium-121m	10	Cesium-125	1,000

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Cesium-127	1,000	Praseodymium-142m	1,000
Cesium-129	1,000	Praseodymium-142	100
Cesium-130	1,000	Praseodymium-143	100
Cesium-131	1,000	Praseodymium-144	1,000
Cesium-132	100	Praseodymium-145	100
Cesium-134m	1,000	Praseodymium-147	1,000
Cesium-134	10	Neodymium-136	1,000
Cesium-135m	1,000	Neodymium-138	100
Cesium-135	100	Neodymium-139m	1,000
Cesium-136	10	Neodymium-139	1,000
Cesium-137	10	Neodymium-141	1,000
Cesium-138	1,000	Neodymium-147	100
Barium-126	1,000	Neodymium-149	1,000
Barium-128	100	Neodymium-151	1,000
Barium-131m	1,000	Promethium-141	1,000
Barium-131	100	Promethium-143	100
Barium-133m	100	Promethium-144	10
Barium-133	100	Promethium-145	10
Barium-135m	100	Promethium-146	1
Barium-139	1,000	Promethium-147	10
Barium-140	100	Promethium-148m	10
Barium-141	1,000	Promethium-148	10
Barium-142	1,000	Promethium-149	100
Lanthanum-131	1,000	Promethium-150	1,000
Lanthanum-132	100	Promethium-151	100
Lanthanum-135	1,000	Samarium-141m	1,000
Lanthanum-137	10	Samarium-141	1,000
Lanthanum-138	100	Samarium-142	1,000
Lanthanum-140	100	Samarium-145	100
Lanthanum-141	100	Samarium-146	1
Lanthanum-142	1,000	Samarium-147	100
Lanthanum-143	1,000	Samarium-151	10
Cerium-134	100	Samarium-153	100
Cerium-135	100	Samarium-155	1,000
Cerium-137m	100	Samarium-156	1,000
Cerium-137	1,000	Europium-145	100
Cerium-139	100	Europium-146	100
Cerium-141	100	Europium-147	100
Cerium-143	100	Europium-148	10
Cerium-144	1	Europium-149	100
Praseodymium-136	1,000	Europium-150 (12.62 h)	100
Praseodymium-137	1,000	Europium-150 (34.2 y)	1
Praseodymium-138m	1,000	Europium-152m	100
Praseodymium-139	1,000	Europium-152	1

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Europium-154	1	Erbium-161	1,000
Europium-155	10	Erbium-165	1,000
Europium-156	100	Erbium-169	100
Europium-157	100	Erbium-171	100
Europium-158	1,000	Erbium-172	100
Gadolinium-145	1,000	Thulium-162	1,000
Gadolinium-146	10	Thulium-166	100
Gadolinium-147	100	Thulium-167	100
Gadolinium-148	0.001	Thulium-170	10
Gadolinium-149	100	Thulium-171	10
Gadolinium-151	10	Thulium-172	100
Gadolinium-152	100	Thulium-173	100
Gadolinium-153	10	Thulium-175	1,000
Gadolinium-159	100	Ytterbium-162	1,000
Terbium-147	1,000	Ytterbium-166	100
Terbium-149	100	Ytterbium-167	1,000
Terbium-150	1,000	Ytterbium-169	100
Terbium-151	100	Ytterbium-175	100
Terbium-153	1,000	Ytterbium-177	1,000
Terbium-154	100	Ytterbium-178	1,000
Terbium-155	1,000	Lutetium-169	100
Terbium-156m (5.0 h)	1,000	Lutetium-170	100
Terbium-156m (24.4 h)	1,000	Lutetium-171	100
Terbium-156	100	Lutetium-172	100
Terbium-157	10	Lutetium-173	10
Terbium-158	1	Lutetium-174m	10
Terbium-160	10	Lutetium-174	10
Terbium-161	100	Lutetium-176m	1,000
Dysprosium-155	1,000	Lutetium-176	100
Dysprosium-157	1,000	Lutetium-177m	10
Dysprosium-159	100	Lutetium-177	100
Dysprosium-165	1,000	Lutetium-178m	1,000
Dysprosium-166	100	Lutetium-178	1,000
Holmium-155	1,000	Lutetium-179	1,000
Holmium-157	1,000	Hafnium-170	100
Holmium-159	1,000	Hafnium-172	1
Holmium-161	1,000	Hafnium-173	1,000
Holmium-162m	1,000	Hafnium-175	100
Holmium-162	1,000	Hafnium-177m	1,000
Holmium-164m	1,000	Hafnium-178m	0.1
Holmium-164	1,000	Hafnium-179m	10
Holmium-166m	1	Hafnium-180m	1,000
Holmium-166	100	Hafnium-181	10
Holmium-167	1,000	Hafnium-182m	1,000

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Hafnium-182	0.1	Osmium-189m	1,000
Hafnium-183	1,000	Osmium-191m	1,000
Hafnium-184	100	Osmium-191	100
Tantalum-172	1,000	Osmium-193	100
Tantalum-173	1,000	Osmium-194	1
Tantalum-174	1,000	Iridium-182	1,000
Tantalum-175	1,000	Iridium-184	1,000
Tantalum-176	100	Iridium-185	1,000
Tantalum-177	1,000	Iridium-186	100
Tantalum-178	1,000	Iridium-187	1,000
Tantalum-179	100	Iridium-188	100
Tantalum-180m	1,000	Iridium-189	100
Tantalum-180	100	Iridium-190m	1,000
Tantalum-182m	1,000	Iridium-190	100
Tantalum-182	10	Iridium-192m (1.4 min)	10
Tantalum-183	100	Iridium-192 (73.8 d)	1
Tantalum-184	100	Iridium-194m	10
Tantalum-185	1,000	Iridium-194	100
Tantalum-186	1,000	Iridium-195m	1,000
Tungsten-176	1,000	Iridium-195	1,000
Tungsten-177	1,000	Platinum-186	1,000
Tungsten-178	1,000	Platinum-188	100
Tungsten-179	1,000	Platinum-189	1,000
Tungsten-181	1,000	Platinum-191	100
Tungsten-185	100	Platinum-193m	100
Tungsten-187	100	Platinum-193	1,000
Tungsten-188	10	Platinum-195m	100
Rhenium-177	1,000	Platinum-197m	1,000
Rhenium-178	1,000	Platinum-197	100
Rhenium-181	1,000	Platinum-199	1,000
Rhenium-182 (12.7 h)	1,000	Platinum-200	100
Rhenium-182 (64.0 h)	100	Gold-193	1,000
Rhenium-184m	10	Gold-194	100
Rhenium-184	100	Gold-195	10
Rhenium-186m	10	Gold-198m	100
Rhenium-186	100	Gold-198	100
Rhenium-187	1,000	Gold-199	100
Rhenium-188m	1,000	Gold-200m	100
Rhenium-188	100	Gold-200	1,000
Rhenium-189	100	Gold-201	1,000
Osmium-180	1,000	Mercury-193m	100
Osmium-181	1,000	Mercury-193	1,000
Osmium-182	100	Mercury-194	1
Osmium-185	100	Mercury-195m	100

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Mercury-195	1,000	Polonium-207	1,000
Mercury-197m	100	Polonium-210	0.1
Mercury-197	1,000	Astatine-207	100
Mercury-199m	1,000	Astatine-211	10
Mercury-203	100	Radon-220	1
Thallium-194m	1,000	Radon-222	1
Thallium-194	1,000	Francium-222	100
Thallium-195	1,000	Francium-223	100
Thallium-197	1,000	Radium-223	0.1
Thallium-198m	1,000	Radium-224	0.1
Thallium-198	1,000	Radium-225	0.1
Thallium-199	1,000	Radium-226	0.1
Thallium-201	1,000	Radium-227	1,000
Thallium-200	1,000	Radium-228	0.1
Thallium-202	100	Actinium-224	1
Thallium-204	100	Actinium-225	0.01
Lead-195m	1,000	Actinium-226	0.1
Lead-198	1,000	Actinium-227	0.001
Lead-199	1,000	Actinium-228	1
Lead-200	100	Thorium-226	10
Lead-201	1,000	Thorium-227	0.01
Lead-202m	1,000	Thorium-228	0.001
Lead-202	10	Thorium-229	0.001
Lead-203	1,000	Thorium-230	0.001
Lead-205	100	Thorium-231	100
Lead-209	1,000	Thorium-232	100
Lead-210	0.01	Thorium-234	10
Lead-211	100	Thorium-natural	100
Lead-212	1	Protactinium-227	10
Lead-214	100	Protactinium-228	1
Bismuth-200	1,000	Protactinium-230	0.1
Bismuth-201	1,000	Protactinium-231	0.001
Bismuth-202	1,000	Protactinium-232	1
Bismuth-203	100	Protactinium-233	100
Bismuth-205	100	Protactinium-234	100
Bismuth-206	100	Uranium-230	0.01
Bismuth-207	10	Uranium-231	100
Bismuth-210m	0.1	Uranium-232	0.001
Bismuth-210	1	Uranium-233	0.001
Bismuth-212	10	Uranium-234	0.001
Bismuth-213	10	Uranium-235	0.001
Bismuth-214	100	Uranium-236	0.001
Polonium-203	1,000	Uranium-237	100
Polonium-205	1,000	Uranium-238	100

^b To convert μCi to kBq , multiply the μCi value by 37.

Radionuclide	Quantity (μCi) ^b	Radionuclide	Quantity (μCi) ^b
Uranium-239	1,000	Curium-240	0.1
Uranium-240	100	Curium-241	1
Uranium-natural	100	Curium-242	0.01
Neptunium-232	100	Curium-243	0.001
Neptunium-233	1,000	Curium-244	0.001
Neptunium-234	100	Curium-245	0.001
Neptunium-235	100	Curium-246	0.001
Neptunium-236 (1.15E+5 y)	0.001	Curium-247	0.001
Neptunium-236 (22.5 h)	1	Curium-248	0.001
Neptunium-237	0.001	Curium-249	1,000
Neptunium-238	10	Berkelium-245	100
Neptunium-239	100	Berkelium-246	100
Neptunium-240	1,000	Berkelium-247	0.001
Plutonium-234	10	Berkelium-249	0.1
Plutonium-235	1,000	Berkelium-250	10
Plutonium-236	0.001	Californium-244	100
Plutonium-237	100	Californium-246	1
Plutonium-238	0.001	Californium-248	0.01
Plutonium-239	0.001	Californium-249	0.001
Plutonium-240	0.001	Californium-250	0.001
Plutonium-241	0.01	Californium-251	0.001
Plutonium-242	0.001	Californium-252	0.001
Plutonium-243	1,000	Californium-253	0.1
Plutonium-244	0.001	Californium-254	0.001
Plutonium-245	100	Einsteinium-250	100
Americium-237	1,000	Einsteinium-251	100
Americium-238	100	Einsteinium-253	0.1
Americium-239	1,000	Einsteinium-254m	1
Americium-240	100	Einsteinium-254	0.01
Americium-241	0.001	Fermium-252	1
Americium-242m	0.001	Fermium-253	1
Americium-242	10	Fermium-254	10
Americium-243	0.001	Fermium-255	1
Americium-244m	100	Fermium-257	0.01
Americium-244	10	Mendelevium-257	10
Americium-245	1,000	Mendelevium-258	0.01
Americium-246m	1,000	Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001
Americium-246	1,000	Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01
Curium-238	100		

^b To convert μCi to kBq , multiply the μCi value by 37.

NOTE: For purposes of 3701:1-38-18(A)(4), 3701:1-38-18(E), and 3701:1-38-21(A) where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" -- that is, unity.

^{a/} The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of the appendix to rule 3701:1-38-12, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μ Ci). Values of 3.7 MBq (100 μ Ci) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μ Ci), to take into account their low specific activity.

^{b/} To convert μ Ci to kBq, multiply the μ Ci value by 37.