Chapter DHS 157

APPENDIX F

Quantities of Licensed Material Requiring Labeling (in Atomic Order)

Note: To convert uCi to kBq, multiply the uCi value by 37.

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Hydrogen–3	1,000	Manganese–51	1,000
Beryllium–7	1,000	Manganese–52m	1,000
Beryllium–10	1	Manganese–52	100
Carbon–11	1,000	Manganese–53	1,000
Carbon–14	100	Manganese–54	100
Fluorine–18	1,000	Manganese–56	1,000
Sodium–22	10	Iron–52	100
Sodium–24	100	Iron–55	100
Magnesium–28	100	Iron–59	10
Aluminum–26	10	Iron–60	1
Silicon–31	1,000	Cobalt–55	100
Silicon–32	1	Cobalt–56	10
Phosphorus–32	10	Cobalt–57	100
Phosphorus–33	100	Cobalt–58m	1,000
Sulfur–35	100	Cobalt–58	100
Chlorine–36	10	Cobalt–60m	1,000
Chlorine–38	1,000	Cobalt–60	1
Chlorine–39	1,000	Cobalt–61	1,000
Argon–39	1,000	Cobalt–62m	1,000
Argon–41	1,000	Nickel–56	100
Potassium–40	100	Nickel–57	100
Potassium–42	1,000	Nickel–59	100
Potassium–43	1,000	Nickel–63	100
Potassium–44	1,000	Nickel–65	1,000
Potassium–45	1,000	Nickel–66	10
Calcium–41	100	Copper–60	1,000
Calcium–45	100	Copper–61	1,000
Calcium–47	100	Copper–64	1,000
Scandium–43	1,000	Copper–67	1,000
Scandium–44m	100	Zinc–62	100
Scandium–44	100	Zinc–63	1,000
Scandium–46	10	Zinc–65	10
Scandium–47	100	Zinc–69m	100
Scandium–48	100	Zinc–69	1,000
Scandium–49	1,000	Zinc–71m	1,000
Titanium–44	1	Zinc–72	100
Titanium–45	1,000	Gallium–65	1,000
Vanadium–47	1,000	Gallium–66	100
Vanadium–48	100	Gallium–67	1,000
Vanadium–49	1,000	Gallium–68	1,000
Chromium–48	1,000	Gallium–70	1,000
Chromium–49	1,000	Gallium–72	100
Chromium–51	1,000	Gallium–73	1,000

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Germanium–66	1,000	Rubidium–87	100
Germanium–67	1,000	Rubidium–88	1,000
Germanium–68	10	Rubidium–89	1,000
Germanium–69	1,000	Strontium–80	100
Germanium–71	1,000	Strontium–81	1,000
Germanium–75	1,000	Strontium–83	100
Germanium–77	1,000	Strontium–85m	1,000
Germanium–78	1,000	Strontium–85	100
Arsenic–69	1,000	Strontium–87m	1,000
Arsenic–70	1,000	Strontium–89	10
Arsenic–71	100	Strontium–90	0.1
Arsenic–72	100	Strontium–91	100
Arsenic–73	100	Strontium–92	100
Arsenic–74	100	Yttrium–86m	1,000
Arsenic–76	100	Yttrium–86	100
Arsenic–77	100	Yttrium–87	100
Arsenic–78	1,000	Yttrium–88	10
Selenium–70	1,000	Yttrium–90m	1,000
Selenium–73m	1,000	Yttrium–90	10
Selenium–73	100	Yttrium–91m	1,000
Selenium–75	100	Yttrium–91	10
Selenium–79	100	Yttrium–92	100
Selenium–81m	1,000	Yttrium–93	100
Selenium–81	1,000	Yttrium–94	1,000
Selenium–83	1,000	Yttrium–95	1,000
Bromine–74m	1,000	Zirconium–86	100
Bromine–74	1,000	Zirconium–88	10
Bromine–75	1,000	Zirconium–89	100
Bromine–76	100	Zirconium–93	1
Bromine–77	1,000	Zirconium–95	10
Bromine–80m	1,000	Zirconium–97	100
Bromine–80	1,000	Niobium–88	1,000
Bromine–82	100	Niobium–89m (66 min)	1,000
Bromine–83	1,000	Niobium–89 (122 min)	1,000
Bromine–84	1,000	Niobium–90	100
Krypton–74	1,000	Niobium–93m	10
Krypton–76	1,000	Niobium–94	1
Krypton–77	1,000	Niobium–95m	100
Krypton–79	1,000	Niobium–95	100
Krypton–81	1,000	Niobium–96	100
Krypton–83m	1,000	Niobium–97	1,000
Krypton–85m	1,000	Niobium–98	1,000
Krypton–85	1,000	Molybdenum–90	100
Krypton–87	1,000	Molybdenum–93m	100
Krypton–88	1,000	Molybdenum–93	10
Rubidium–79	1,000	Molybdenum–99	100
Rubidium–81m	1,000	Molybdenum–101	1,000
Rubidium–81	1,000	Technetium–93m	1,000
Rubidium–82m	1,000	Technetium–93	1,000
Rubidium–83	100	Technetium–94m	1,000
Rubidium–84	100	Technetium–94	1,000
Rubidium–86	100	Technetium–96m	1,000

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Technetium–96	100	Indium–110 (4.9 h)	1,000
Technetium–97m	100	Indium–111	100
Technetium–97	1,000	Indium–112	1,000
Technetium–98	10	Indium–113m	1,000
Technetium–99m	1,000	Indium–114m	10
Technetium–99	100	Indium–115m	1,000
Technetium–101	1,000	Indium–115	100
Technetium–104	1,000	Indium–116m	1,000
Ruthenium–94	1,000	Indium–117m	1,000
Ruthenium–97	1,000	Indium–117	1,000
Ruthenium–103	100	Indium–119m	1,000
Ruthenium–105	1,000	Tin–110	100
Ruthenium–106	1	Tin–111	1,000
Rhodium–99m	1,000	Tin–113	100
Rhodium–99	100	Tin–117m	100
Rhodium–100	100	Tin–119m	100
Rhodium–101m	1,000	Tin–121m	100
Rhodium–101	10	Tin–121	1,000
Rhodium–102m	10	Tin–123m	1,000
Rhodium–102	10	Tin–123	10
Rhodium–103m	1,000	Tin–125	10
Rhodium–105	100	Tin–126	10
Rhodium–106m	1,000	Tin–127	1,000
Rhodium–107	1,000	Tin–128	1,000
Palladium–100	100	Antimony–115	1,000
Palladium–101	1,000	Antimony–116m	1,000
Palladium–103	100	Antimony–116	1,000
Palladium–107	10	Antimony–117	1,000
Palladium–109	100	Antimony–118m	1,000
Silver–102	1,000	Antimony–119	1,000
Silver–103	1,000	Antimony–120 (16 min)	1,000
Silver–104m	1,000	Antimony–120 (5.76 d)	100
Silver–104	1,000	Antimony–122	100
Silver–105	100	Antimony–124m	1,000
Silver–106m	100	Antimony–124	10
Silver–106	1,000	Antimony–125	100
Silver–108m	1	Antimony–126m	1,000
Silver–11Om	10	Antimony–126	100
Silver–111	100	Antimony–127	100
Silver–112	100	Antimony–128 (10.4 min)	1,000
Silver–115	1,000	Antimony–128 (9.01 h)	100
Cadmium–104	1,000	Antimony–129	100
Cadmium–107	1,000	Antimony–130	1,000
Cadmium–109	1	Antimony–131	1,000
Cadmium–113m	0.1	Tellurium–116	1,000
Cadmium–113	100	Tellurium–121m	10
Cadmium–115m	10	Tellurium–121	100
Cadmium–115	100	Tellurium–123m	10
Cadmium–117m	1,000	Tellurium–123	100
Cadmium–117	1,000	Tellurium–125m	10
Indium–109	1,000	Tellurium–127m	10
Indium–110 (69.1 min)	1,000	Tellurium–127	1,000

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Tellurium–129m	10	Barium–131m	1,000
Tellurium–129	1,000	Barium–131	100
Tellurium–131m	10	Barium–133m	100
Tellurium–131	100	Barium–133	100
Tellurium–132	10	Barium–135m	100
Tellurium–133m	100	Barium–139	1,000
Tellurium–133	1,000	Barium–140	100
Tellurium–134	1,000	Barium–141	1,000
Iodine–120m	1,000	Barium–142	1,000
Iodine–120	100	Lanthanum–131	1,000
Iodine–121	1,000	Lanthanum–132	100
Iodine–123	100	Lanthanum–135	1,000
Iodine–124	10	Lanthanum–137	10
Iodine–125	1	Lanthanum–138	100
Iodine–126	1	Lanthanum–140	100
Iodine–128	1,000	Lanthanum–141	100
Iodine–129	1	Lanthanum–142	1,000
Iodine–130	10	Lanthanum–143	1,000
Iodine–131	1	Cerium–134	100
Iodine–132m	100	Cerium–135	100
Iodine–132	100	Cerium–137m	100
Iodine–133	10	Cerium–137	1,000
Iodine–134	1,000	Cerium–139	100
Iodine–135	100	Cerium–141	100
Xenon–120	1,000	Cerium–143	100
Xenon–121	1,000	Cerium–144	1
Xenon–122	1,000	Praseodymium–136	1,000
Xenon–123	1,000	Praseodymium–137	1,000
Xenon–125	1,000	Praseodymium–138m	1,000
Xenon–127	1,000	Praseodymium–139	1,000
Xenon–129m	1,000	Praseodymium–142m	1,000
Xenon–131m	1,000	Praseodymium–142	100
Xenon–133m	1,000	Praseodymium–143	100
Xenon–133	1,000	Praseodymium–144	1,000
Xenon–135m	1,000	Praseodymium–145	100
Xenon–135	1,000	Praseodymium–147	1,000
Xenon–138	1,000	Neodymium–136	1,000
Cesium–125	1,000	Neodymium–138	100
Cesium–127	1,000	Neodymium–139m	1,000
Cesium–129	1,000	Neodymium–139	1,000
Cesium–130	1,000	Neodymium–141	1,000
Cesium–131	1,000	Neodymium–147	100
Cesium–132	100	Neodymium–149	1,000
Cesium–134m	1,000	Neodymium–151	1,000
Cesium–134	10	Promethium–141	1,000
Cesium–135m	1,000	Promethium–143	100
Cesium–135	100	Promethium–144	10
Cesium–136	10	Promethium–145	10
Cesium–137	10	Promethium–146	1
Cesium–138	1,000	Promethium–147	10
Barium–126	1,000	Promethium–148m	10
Barium–128	100	Promethium–148	10

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Promethium–149	100	Dysprosium–159	100
Promethium–150	1,000	Dysprosium–165	1,000
Promethium–151	100	Dysprosium–166	100
Samarium–141m	1,000	Holmium–155	1,000
Samarium–141	1,000	Holmium–157	1,000
Samarium–142	1,000	Holmium–159	1,000
Samarium–145	100	Holmium–161	1,000
Samarium–146	1	Holmium–162m	1,000
Samarium–147	100	Holmium–162	1,000
Samarium–151	10	Holmium–164m	1,000
Samarium–153	100	Holmium–164	1,000
Samarium–155	1,000	Holmium–166m	1
Samarium–156	1,000	Holmium–166	100
Europium–145	100	Holmium–167	1,000
Europium–146	100	Erbium–161	1,000
Europium–147	100	Erbium–165	1,000
Europium–148	10	Erbium–169	100
Europium–149	100	Erbium–171	100
Europium–150 (12.62 h)	100	Erbium–172	100
Europium–150 (34.2 y)	1	Thulium–162	1,000
Europium–152m	100	Thulium–166	100
Europium–152	1	Thulium–167	100
Europium–154	1	Thulium–170	10
Europium–155	10	Thulium–171	10
Europium–156	100	Thulium–172	100
Europium–157	100	Thulium–173	100
Europium–158	1,000	Thulium–175	1,000
Gadolinium–145	1,000	Ytterbium–162	1,000
Gadolinium–146	10	Ytterbium–166	100
Gadolinium–147	100	Ytterbium–167	1,000
Gadolinium–148	0.001	Ytterbium–169	100
Gadolinium–149	100	Ytterbium–175	100
Gadolinium–151	10	Ytterbium–177	1,000
Gadolinium–152	100	Ytterbium–178	1,000
Gadolinium–153	10	Lutetium–169	100
Gadolinium–159	100	Lutetium–170	100
Terbium–147	1,000	Lutetium–171	100
Terbium–149	100	Lutetium–172	100
Terbium–150	1,000	Lutetium–173	10
Terbium–151	100	Lutetium–174m	10
Terbium–153	1,000	Lutetium–174	10
Terbium–154	100	Lutetium–176m	1,000
Terbium–155	1,000	Lutetium–176	100
Terbium–156m (5.0 h)	1,000	Lutetium–177m	10
Terbium–156m (24.4 h)	1,000	Lutetium–177	100
Terbium–156	100	Lutetium–178m	1,000
Terbium–157	10	Lutetium–178	1,000
Terbium–158	1	Lutetium–179	1,000
Terbium–160	10	Hafnium–170	100
Terbium–161	100	Hafnium–172	1
Dysprosium–155	1,000	Hafnium–173	1,000
Dysprosium–157	1,000	Hafnium–175	100

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Hafnium–177m	1,000	Iridium–195m	1,000
Hafnium–178m	0.1	Iridium–195	1,000
Hafnium–179m	10	Platinum–186	1,000
Hafnium–180m	1,000	Platinum–188	100
Hafnium–181	10	Platinum–189	1,000
Hafnium–182m	1,000	Platinum–191	100
Hafnium–182	0.1	Platinum–193m	100
Hafnium–183	1,000	Platinum–193	1,000
Hafnium–184	100	Platinum–195m	100
Tantalum–172	1,000	Platinum–197m	1,000
Tantalum–173	1,000	Platinum–197	100
Tantalum–174	1,000	Platinum–199	1,000
Tantalum–175	1,000	Platinum–200	100
Tantalum–176	100	Gold–193	1,000
Tantalum–177	1,000	Gold–194	100
Tantalum–178	1,000	Gold–195	10
Tungsten–188	10	Gold–198m	100
Rhenium–177	1,000	Gold–198	100
Rhenium–178	1,000	Gold–199	100
Rhenium–181	1,000	Gold–200m	100
Rhenium–182 (12.7 h)	1,000	Gold–200	1,000
Rhenium–182 (64.0 h)	100	Gold–201	1,000
Rhenium–184m	10	Mercury–193m	100
Rhenium–184	100	Mercury–193	1,000
Rhenium–186m	10	Mercury–194	1
Rhenium–186	100	Mercury–195m	100
Rhenium–187	1,000	Mercury–195	1,000
Rhenium–188m	1,000	Mercury–197m	100
Rhenium–188	100	Mercury–197	1,000
Rhenium–189	100	Mercury–199m	1,000
Osmium–180	1,000	Mercury–203	100
Osmium–181	1,000	Thallium–194m	1,000
Osmium–182	100	Thallium–194	1,000
Osmium–185	100	Thallium–195	1,000
Osmium–189m	1,000	Thallium–197	1,000
Osmium–191m	1,000	Thallium–198m	1,000
Osmium–191	100	Thallium–198	1,000
Osmium–193	100	Thallium–199	1,000
Osmium–194	1	Thallium–201	1,000
Iridium–182	1,000	Thallium–200	1,000
Iridium–184	1,000	Thallium–202	100
Iridium–185	1,000	Thallium–204	100
Iridium–186	100	Lead–195m	1,000
Iridium–187	1,000	Lead–198	1,000
Iridium–188	100	Lead–199	1,000
Iridium–189	100	Lead–200	100
Iridium–190m	1,000	Lead–201	1,000
Iridium–190	100	Lead–202m	1,000
Iridium–192m (1.4 min)	10	Lead–202	10
Iridium–192 (73.8 d)	1	Lead–203	1,000
Iridium–194m	10	Lead–205	100
Iridium–194	100	Lead–209	1,000

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Lead–210	0.01	Protactinium–234	100
Lead–211	100	Uranium–230	0.01
Lead–212	1	Uranium–231	100
Lead–214	100	Uranium–232	0.001
Bismuth–200	1,000	Uranium–233	0.001
Bismuth–201	1,000	Uranium–234	0.001
Bismuth–202	1,000	Uranium–235	0.001
Bismuth–203	100	Uranium–236	0.001
Bismuth–205	100	Uranium–237	100
Bismuth–206	100	Uranium–238	100
Bismuth–207	10	Uranium–239	1,000
Bismuth–210m	0.1	Uranium–240	100
Bismuth–210	1	Uranium–natural	100
Bismuth–212	10	Neptunium–232	100
Bismuth–213	10	Neptunium–233	1,000
Bismuth–214	100	Neptunium–234	100
Polonium–203	1,000	Neptunium–235	100
Polonium–205	1,000	Neptunium–236 (1.15E+5 y)	0.001
Polonium–207	1,000	Neptunium–236 (22.5 h)	1
Polonium–210	0.1	Neptunium–237	0.001
Astatine–207	100	Neptunium–238	10
Astatine–211	10	Neptunium–239	100
Radon–220	1	Neptunium–240	1,000
Radon–222	1	Plutonium–234	10
Francium–222	100	Plutonium–235	1,000
Francium–223	100	Plutonium–236	0.001
Radium–223	0.1	Plutonium–237	100
Radium–224	0.1	Plutonium–238	0.001
Radium–225	0.1	Plutonium–239	0.001
Radium–226	0.1	Plutonium–240	0.001
Radium–227	1,000	Plutonium–241	0.01
Radium–228	0.1	Plutonium–242	0.001
Actinium–224	1	Plutonium–243	1,000
Actinium–225	0.01	Plutonium–244	0.001
Actinium–226	0.1	Plutonium–245	100
Actinium–227	0.001	Americium–237	1,000
Actinium–228	1	Americium–238	100
Thorium–226	10	Americium–239	1,000
Thorium–227	0.01	Americium–240	100
Thorium–228	0.001	Americium–241	0.001
Thorium–229	0.001	Americium–242m	0.001
Thorium–230	0.001	Americium–242	10
Thorium–231	100	Americium–243	0.001
Thorium–232	100	Americium–244m	100
Thorium–234	10	Americium–244	10
Thorium–natural	100	Americium–245	1,000
Protactinium–227	10	Americium–246m	1,000
Protactinium–228	1	Americium–246	1,000
Protactinium–230	0.1	Curium–238	100
Protactinium–231	0.001	Curium–240	0.1
Protactinium–232	1	Curium–241	1
Protactinium–233	100		

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Curium–242	0.01	Californium–250	0.001
Curium–243	0.001	Californium–251	0.001
Curium–244	0.001	Californium–252	0.001
Curium–245	0.001	Californium–253	0.1
Curium–246	0.001	Californium–254	0.001
Curium–247	0.001	Einsteinium–250	100
Curium–248	0.001	Einsteinium–251	100
Curium–249	1,000	Einsteinium–253	0.1
Berkelium–245	100	Einsteinium–254m	1
Berkelium–246	100	Einsteinium–254	0.01
Berkelium–247	0.001	Fermium–252	1
Berkelium–249	0.1	Fermium–253	1
Berkelium–250	10	Fermium–254	10
Californium–244	100	Fermium–255	1
Californium–246	1	Fermium–257	0.01
Californium–248	0.01	Mendelevium–257	10
Californium–249	0.001	Mendelevium–258	0.01
Any alpha–emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001		
Any radionuclide other than alpha–emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01		

Note: For purposes of s. DHS 157.29 (2) (e), (5) (a) and s. DHS 157.32 (1) (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.

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