| | | Table I Occupational Values | | | Table II Effluent Concentrations | | Table III Releases to Sewers |
|---|---|---|---|---|---|---|---|
| | | Col. 1 | Col. 2 | Col. 3 | Col. 1 | Col. 2 | |
| | | Oral Ingestion | INHALATION | | | | Monthly Average |
| Atomic Radio-nuclide No. | Class | ALI (μCi) | ALI (μCi) | DAC (μCi/ml) | Air (μCi/ml) | Water (μCi/ml) | Concentration (μCi/ml) |

Example: If radionuclides "A," "B," and "C" are present in concentrations $C_A$, $C_B$, and $C_C$, and if the applicable DACs are $DAC_A$, $DAC_B$, and $DAC_C$, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1$$

## CHAPTER 40

## APPENDIX C

## QUANTITIES[1] OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

| Radionuclide | Quantity (μCi)* | Radionuclide | Quantity (μCi)* |
|---|---|---|---|
| Hydrogen-3 | 1,000 | Chromium-48 | 1,000 |
| Beryllium-7 | 1,000 | Chromium-49 | 1,000 |
| Beryllium-10 | 1 | Chromium-51 | 1,000 |
| Carbon-11 | 1,000 | Manganese-51 | 1,000 |
| Carbon-14 | 100 | Manganese-52m | 1,000 |
| Fluorine-18 | 1,000 | Manganese-52 | 100 |
| Sodium-22 | 10 | Manganese-53 | 1,000 |
| Sodium-24 | 100 | Manganese-54 | 100 |
| Magnesium-28 | 100 | Manganese-56 | 1,000 |
| Aluminum-26 | 10 | Iron-52 | 100 |
| Silicon-31 | 1,000 | Iron-55 | 100 |
| Silicon-32 | 1 | Iron-59 | 10 |
| Phosphorus-32 | 10 | Iron-60 | 1 |
| Phosphorus-33 | 100 | Cobalt-55 | 100 |
| Sulfur-35 | 100 | Cobalt-56 | 10 |
| Chlorine-36 | 10 | Cobalt-57 | 100 |
| Chlorine-38 | 1,000 | Cobalt-58m | 1,000 |
| Chlorine-39 | 1,000 | Cobalt-58 | 100 |
| Argon-39 | 1,000 | Cobalt-60m | 1,000 |
| Argon-41 | 1,000 | Cobalt-60 | 1 |

| | | | |
|---|---|---|---|
| Potassium-40 | 100 | Cobalt-61 | 1,000 |
| Potassium-42 | 1,000 | Cobalt-62m | 1,000 |
| Potassium-43 | 1,000 | Nickel-56 | 100 |
| Potassium-44 | 1,000 | Nickel-57 | 100 |
| Potassium-45 | 1,000 | Nickel-59 | 100 |
| Calcium-41 | 100 | Nickel-63 | 100 |
| Calcium-45 | 100 | Nickel-65 | 1,000 |
| Calcium-47 | 100 | Nickel-66 | 10 |
| Scandium-43 | 1,000 | Copper-60 | 1,000 |
| Scandium-44m | 100 | Copper-61 | 1,000 |
| Scandium-44 | 100 | Copper-64 | 1,000 |
| Scandium-46 | 10 | Copper-67 | 1,000 |
| Scandium-47 | 100 | Zinc-62 | 100 |
| Scandium-48 | 100 | Zinc-63 | 1,000 |
| Scandium-49 | 1,000 | Zinc-65 | 10 |
| Titanium-44 | 1 | Zinc-69m | 100 |
| Titanium-45 | 1,000 | Zinc-69 | 1,000 |
| Vanadium-47 | 1,000 | Zinc-71m | 1,000 |
| Vanadium-48 | 100 | Zinc-72 | 100 |
| Vanadium-49 | 1,000 | Gallium-65 | 1,000 |

| | |
|---|---|
| Gallium-66 | 100 |
| Gallium-67 | 1,000 |
| Gallium-68 | 1,000 |
| Gallium-70 | 1,000 |
| Gallium-72 | 100 |
| Gallium-73 | 1,000 |
| Germanium-66 | 1,000 |
| Germanium-67 | 1,000 |
| Germanium-68 | 10 |
| Germanium-69 | 1,000 |
| Germanium-71 | 1,000 |
| Germanium-75 | 1,000 |
| Germanium-77 | 1,000 |
| Germanium-78 | 1,000 |
| Arsenic-69 | 1,000 |
| Arsenic-70 | 1,000 |
| Arsenic-71 | 100 |
| Arsenic-72 | 100 |
| Arsenic-73 | 100 |
| Arsenic-74 | 100 |
| Arsenic-76 | 100 |
| Arsenic-77 | 100 |
| Arsenic-78 | 1,000 |
| Selenium-70 | 1,000 |
| Selenium-73m | 1,000 |
| Selenium-73 | 100 |
| Selenium-75 | 100 |
| Selenium-79 | 100 |
| Selenium-81m | 1,000 |
| Selenium-81 | 1,000 |
| Selenium-83 | 1,000 |
| Bromine-74m | 1,000 |
| Bromine-74 | 1,000 |
| Bromine-75 | 1,000 |
| Bromine-76 | 100 |
| Bromine-77 | 1,000 |
| Bromine-80m | 1,000 |
| Bromine-80 | 1,000 |
| Bromine-82 | 100 |
| Bromine-83 | 1,000 |
| Bromine-84 | 1,000 |
| Krypton-74 | 1,000 |
| Krypton-76 | 1,000 |
| Krypton-77 | 1,000 |
| Krypton-79 | 1,000 |
| Krypton-81 | 1,000 |
| Krypton-83m | 1,000 |
| Krypton-85m | 1,000 |
| Krypton-85 | 1,000 |
| Krypton-87 | 1,000 |
| Krypton-88 | 1,000 |
| Rubidium-79 | 1,000 |
| Rubidium-81m | 1,000 |
| Rubidium-81 | 1,000 |
| Rubidium-82m | 1,000 |
| Rubidium-83 | 100 |
| Rubidium-84 | 100 |
| Rubidium-86 | 100 |
| Rubidium-87 | 100 |
| Rubidium-88 | 1,000 |
| Rubidium-89 | 1,000 |
| Strontium-80 | 100 |
| Strontium-81 | 1,000 |
| Strontium-83 | 100 |
| Strontium-85m | 1,000 |
| Strontium-85 | 100 |
| Strontium-87m | 1,000 |
| Strontium-89 | 10 |
| Strontium-90 | 0.1 |
| Strontium-91 | 100 |
| Strontium-92 | 100 |
| Yttrium-86m | 1,000 |
| Yttrium-86 | 100 |
| Yttrium-87 | 100 |
| Yttrium-88 | 10 |
| Yttrium-90m | 1,000 |
| Yttrium-90 | 10 |
| Yttrium-91m | 1,000 |
| Yttrium-91 | 10 |
| Yttrium-92 | 100 |
| Yttrium-93 | 100 |
| Yttrium-94 | 1,000 |
| Yttrium-95 | 1,000 |
| Zirconium-86 | 100 |
| Zirconium-88 | 10 |
| Zirconium-89 | 100 |
| Zirconium-93 | 1 |
| Zirconium-95 | 10 |
| Zirconium-97 | 100 |

| | |
|---|---|
| Niobium-88 | 1,000 |
| Niobium-89m (66 min) | 1,000 |
| Niobium-89 (122 min) | 1,000 |
| Niobium-90 | 100 |
| Niobium-93m | 10 |
| Niobium-94 | 1 |
| Niobium-95m | 100 |
| Niobium-95 | 100 |
| Niobium-96 | 100 |
| Niobium-97 | 1,000 |
| Niobium-98 | 1,000 |
| Molybdenum-90 | 100 |
| Molybdenum-93m | 100 |
| Molybdenum-93 | 10 |
| Molybdenum-99 | 100 |
| Molybdenum-101 | 1,000 |
| Technetium-93m | 1,000 |
| Technetium-93 | 1,000 |
| Technetium-94m | 1,000 |
| Technetium-94 | 1,000 |
| Technetium-96m | 1,000 |
| Technetium-96 | 100 |
| Technetium-97m | 100 |
| Technetium-97 | 1,000 |
| Technetium-98 | 10 |
| Technetium-99m | 1,000 |
| Technetium-99 | 100 |
| Technetium-101 | 1,000 |
| Technetium-104 | 1,000 |
| Ruthenium-94 | 1,000 |
| Ruthenium-97 | 1,000 |
| Ruthenium-103 | 100 |
| Ruthenium-105 | 1,000 |
| Ruthenium-106 | 1 |
| Rhodium-99m | 1,000 |
| Rhodium-99 | 100 |
| Rhodium-100 | 100 |
| Rhodium-101m | 1,000 |
| Rhodium-101 | 10 |
| Rhodium-102m | 10 |
| Rhodium-102 | 10 |
| Rhodium-103m | 1,000 |
| Rhodium-105 | 100 |
| Rhodium-106m | 1,000 |
| Rhodium-107 | 1,000 |
| Palladium-100 | 100 |
| Palladium-101 | 1,000 |
| Palladium-103 | 100 |
| Palladium-107 | 10 |
| Palladium-109 | 100 |
| Silver-102 | 1,000 |
| Silver-103 | 1,000 |
| Silver-104m | 1,000 |
| Silver-104 | 1,000 |
| Silver-105 | 100 |
| Silver-106m | 100 |
| Silver-106 | 1,000 |
| Silver-108m | 1 |
| Silver-110m | 10 |
| Silver-111 | 100 |
| Silver-112 | 100 |
| Silver-115 | 1,000 |
| Cadmium-104 | 1,000 |
| Cadmium-107 | 1,000 |
| Cadmium-109 | 1 |
| Cadmium-113m | 0.1 |
| Cadmium-113 | 100 |
| Cadmium-115m | 10 |
| Cadmium-115 | 100 |
| Cadmium-117m | 1,000 |
| Cadmium-117 | 1,000 |
| Indium-109 | 1,000 |
| Indium-110m (69.1m) | 1,000 |
| Indium-110 (4.9h) | 1,000 |
| Indium-111 | 100 |
| Indium-112 | 1,000 |
| Indium-113m | 1,000 |
| Indium-114m | 10 |
| Indium-115m | 1,000 |
| Indium-115 | 100 |
| Indium-116m | 1,000 |
| Indium-117m | 1,000 |
| Indium-117 | 1,000 |
| Indium-119m | 1,000 |
| Tin-110 | 100 |
| Tin-111 | 1,000 |
| Tin-113 | 100 |
| Tin-117m | 100 |
| Tin-119m | 100 |
| Tin-121m | 100 |
| Tin-121 | 1,000 |

| | | | |
|---|---|---|---|
| Tin-123m | 1,000 | Tellurium-133 | 1,000 |
| Tin-123 | 10 | Tellurium-134 | 1,000 |
| Tin-125 | 10 | Iodine-120m | 1,000 |
| Tin-126 | 10 | Iodine-120 | 100 |
| Tin-127 | 1,000 | Iodine-121 | 1,000 |
| Tin-128 | 1,000 | Iodine-123 | 100 |
| Antimony-115 | 1,000 | Iodine-124 | 10 |
| Antimony-116m | 1,000 | Iodine-125 | 1 |
| Antimony-116 | 1,000 | Iodine-126 | 1 |
| Antimony-117 | 1,000 | Iodine-128 | 1,000 |
| Antimony-118m | 1,000 | Iodine-129 | 1 |
| Antimony-119 | 1,000 | Iodine-130 | 10 |
| Antimony-120 (16m) | 1,000 | Iodine-131 | 1 |
| | | Iodine-132m | 100 |
| Antimony-120 (5.76d) | 100 | Iodine-132 | 100 |
| | | Iodine-133 | 10 |
| Antimony-122 | 100 | Iodine-134 | 1,000 |
| Antimony-124m | 1,000 | Iodine-135 | 100 |
| Antimony-124 | 10 | Xenon-120 | 1,000 |
| Antimony-125 | 100 | Xenon-121 | 1,000 |
| Antimony-126m | 1,000 | Xenon-122 | 1,000 |
| Antimony-126 | 100 | Xenon-123 | 1,000 |
| Antimony-127 | 100 | Xenon-125 | 1,000 |
| Antimony-128 (10.4m) | 1,000 | Xenon-127 | 1,000 |
| | | Xenon-129m | 1,000 |
| Antimony-128 (9.01h) | 100 | Xenon-131m | 1,000 |
| | | 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 |
| Tellurium-121 | 100 | Cesium-127 | 1,000 |
| Tellurium-123m | 10 | Cesium-129 | 1,000 |
| Tellurium-123 | 100 | Cesium-130 | 1,000 |
| Tellurium-125m | 10 | Cesium-131 | 1,000 |
| Tellurium-127m | 10 | Cesium-132 | 100 |
| Tellurium-127 | 1,000 | Cesium-134m | 1,000 |
| Tellurium-129m | 10 | Cesium-134 | 10 |
| Tellurium-129 | 1,000 | Cesium-135m | 1,000 |
| Tellurium-131m | 10 | Cesium-135 | 100 |
| Tellurium-131 | 100 | Cesium-136 | 10 |
| Tellurium-132 | 10 | Cesium-137 | 10 |
| Tellurium-133m | 100 | Cesium-138 | 1,000 |

| | | | |
|---|---|---|---|
| Barium-126 | 1,000 | Promethium-141 | 1,000 |
| Barium-128 | 100 | Promethium-143 | 100 |
| Barium-131m | 1,000 | Promethium-144 | 10 |
| Barium-131 | 100 | Promethium-145 | 10 |
| Barium-133m | 100 | Promethium-146 | 1 |
| Barium-133 | 100 | Promethium-147 | 10 |
| Barium-135m | 100 | Promethium-148m | 10 |
| Barium-139 | 1,000 | Promethium-148 | 10 |
| Barium-140 | 100 | Promethium-149 | 100 |
| Barium-141 | 1,000 | Promethium-150 | 1,000 |
| Barium-142 | 1,000 | Promethium-151 | 100 |
| Lanthanum-131 | 1,000 | Samarium-141m | 1,000 |
| Lanthanum-132 | 100 | Samarium-141 | 1,000 |
| Lanthanum-135 | 1,000 | Samarium-142 | 1,000 |
| Lanthanum-137 | 10 | Samarium-145 | 100 |
| Lanthanum-138 | 100 | Samarium-146 | 1 |
| Lanthanum-140 | 100 | Samarium-147 | 100 |
| Lanthanum-141 | 100 | Samarium-151 | 10 |
| Lanthanum-142 | 1,000 | Samarium-153 | 100 |
| Lanthanum-143 | 1,000 | Samarium-155 | 1,000 |
| Cerium-134 | 100 | Samarium-156 | 1,000 |
| Cerium-135 | 100 | Europium-145 | 100 |
| Cerium-137m | 100 | Europium-146 | 100 |
| Cerium-137 | 1,000 | Europium-147 | 100 |
| Cerium-139 | 100 | Europium-148 | 10 |
| Cerium-141 | 100 | Europium-149 | 100 |
| Cerium-143 | 100 | Europium-150 | |
| Cerium-144 | 1 | (12.62h) | 100 |
| Praseodymium-136 | 1,000 | Europium-150 | |
| Praseodymium-137 | 1,000 | (34.2y) | 1 |
| Praseodymium-138m | 1,000 | Europium-152m | 100 |
| Praseodymium-139 | 1,000 | Europium-152 | 1 |
| Praseodymium-142m | 1,000 | Europium-154 | 1 |
| Praseodymium-142 | 100 | Europium-155 | 10 |
| Praseodymium-143 | 100 | Europium-156 | 100 |
| Praseodymium-144 | 1,000 | Europium-157 | 100 |
| Praseodymium-145 | 100 | Europium-158 | 1,000 |
| Praseodymium-147 | 1,000 | Gadolinium-145 | 1,000 |
| Neodymium-136 | 1,000 | Gadolinium-146 | 10 |
| Neodymium-138 | 100 | Gadolinium-147 | 100 |
| Neodymium-139m | 1,000 | Gadolinium-148 | 0.001 |
| Neodymium-139 | 1,000 | Gadolinium-149 | 100 |
| Neodymium-141 | 1,000 | Gadolinium-151 | 10 |
| Neodymium-147 | 100 | Gadolinium-152 | 100 |
| Neodymium-149 | 1,000 | Gadolinium-153 | 10 |
| Neodymium-151 | 1,000 | Gadolinium-159 | 100 |

| | | | |
|---|---|---|---|
| Terbium-147 | 1,000 | Ytterbium-162 | 1,000 |
| Terbium-149 | 100 | Ytterbium-166 | 100 |
| Terbium-150 | 1,000 | Ytterbium-167 | 1,000 |
| Terbium-151 | 100 | Ytterbium-169 | 100 |
| Terbium-153 | 1,000 | Ytterbium-175 | 100 |
| Terbium-154 | 100 | Ytterbium-177 | 1,000 |
| Terbium-155 | 1,000 | Ytterbium-178 | 1,000 |
| Terbium-156m (5.0h) | 1,000 | Lutetium-169 | 100 |
| | | Lutetium-170 | 100 |
| Terbium-156m (24.4h) | 1,000 | Lutetium-171 | 100 |
| | | Lutetium-172 | 100 |
| Terbium-156 | 100 | Lutetium-173 | 10 |
| Terbium-157 | 10 | Lutetium-174m | 10 |
| Terbium-158 | 1 | Lutetium-174 | 10 |
| Terbium-160 | 10 | Lutetium-176m | 1,000 |
| Terbium-161 | 100 | Lutetium-176 | 100 |
| Dysprosium-155 | 1,000 | Lutetium-177m | 10 |
| Dysprosium-157 | 1,000 | Lutetium-177 | 100 |
| Dysprosium-159 | 100 | Lutetium-178m | 1,000 |
| Dysprosium-165 | 1,000 | Lutetium-178 | 1,000 |
| Dysprosium-166 | 100 | Lutetium-179 | 1,000 |
| Holmium-155 | 1,000 | Hafnium-170 | 100 |
| Holmium-157 | 1,000 | Hafnium-172 | 1 |
| Holmium-159 | 1,000 | Hafnium-173 | 1,000 |
| Holmium-161 | 1,000 | Hafnium-175 | 100 |
| Holmium-162m | 1,000 | Hafnium-177m | 1,000 |
| Holmium-162 | 1,000 | Hafnium-178m | 0.1 |
| Holmium-164m | 1,000 | Hafnium-179m | 10 |
| Holmium-164 | 1,000 | Hafnium-180m | 1,000 |
| Holmium-166m | 1 | Hafnium-181 | 10 |
| Holmium-166 | 100 | Hafnium-182m | 1,000 |
| Holmium-167 | 1,000 | Hafnium-182 | 0.1 |
| Erbium-161 | 1,000 | Hafnium-183 | 1,000 |
| Erbium-165 | 1,000 | Hafnium-184 | 100 |
| Erbium-169 | 100 | Tantalum-172 | 1,000 |
| Erbium-171 | 100 | Tantalum-173 | 1,000 |
| Erbium-172 | 100 | Tantalum-174 | 1,000 |
| Thulium-162 | 1,000 | Tantalum-175 | 1,000 |
| Thulium-166 | 100 | Tantalum-176 | 100 |
| Thulium-167 | 100 | Tantalum-177 | 1,000 |
| Thulium-170 | 10 | Tantalum-178 | 1,000 |
| Thulium-171 | 10 | Tantalum-179 | 100 |
| Thulium-172 | 100 | Tantalum-180m | 1,000 |
| Thulium-173 | 100 | Tantalum-180 | 100 |
| Thulium-175 | 1,000 | Tantalum-182m | 1,000 |

| | |
|---|---|
| Tantalum-182 | 10 |
| Tantalum-183 | 100 |
| Tantalum-184 | 100 |
| Tantalum-185 | 1,000 |
| Tantalum-186 | 1,000 |
| Tungsten-176 | 1,000 |
| Tungsten-177 | 1,000 |
| Tungsten-178 | 1,000 |
| Tungsten-179 | 1,000 |
| Tungsten-181 | 1,000 |
| Tungsten-185 | 100 |
| Tungsten-187 | 100 |
| Tungsten-188 | 10 |
| Rhenium-177 | 1,000 |
| Rhenium-178 | 1,000 |
| Rhenium-181 | 1,000 |
| Rhenium-182 (12.7h) | 1,000 |
| Rhenium-182 (64.0h) | 100 |
| Rhenium-184m | 10 |
| Rhenium-184 | 100 |
| Rhenium-186m | 10 |
| Rhenium-186 | 100 |
| Rhenium-187 | 1,000 |
| Rhenium-188m | 1,000 |
| Rhenium-188 | 100 |
| Rhenium-189 | 100 |
| Osmium-180 | 1,000 |
| Osmium-181 | 1,000 |
| Osmium-182 | 100 |
| Osmium-185 | 100 |
| Osmium-189m | 1,000 |
| Osmium-191m | 1,000 |
| Osmium-191 | 100 |
| Osmium-193 | 100 |
| Osmium-194 | 1 |
| Iridium-182 | 1,000 |
| Iridium-184 | 1,000 |
| Iridium-185 | 1,000 |
| Iridium-186 | 100 |
| Iridium-187 | 1,000 |
| Iridium-188 | 100 |
| Iridium-189 | 100 |
| Iridium-190m | 1,000 |
| Iridium-190 | 100 |
| Iridium-192m (1.4m) | 10 |
| Iridium-192 (73.8d) | 1 |
| Iridium-194m | 10 |
| Iridium-194 | 100 |
| Iridium-195m | 1,000 |
| Iridium-195 | 1,000 |
| Platinum-186 | 1,000 |
| Platinum-188 | 100 |
| Platinum-189 | 1,000 |
| Platinum-191 | 100 |
| Platinum-193m | 100 |
| Platinum-193 | 1,000 |
| Platinum-195m | 100 |
| Platinum-197m | 1,000 |
| Platinum-197 | 100 |
| Platinum-199 | 1,000 |
| Platinum-200 | 100 |
| Gold-193 | 1,000 |
| Gold-194 | 100 |
| Gold-195 | 10 |
| Gold-198m | 100 |
| Gold-198 | 100 |
| Gold-199 | 100 |
| Gold-200m | 100 |
| Gold-200 | 1,000 |
| Gold-201 | 1,000 |
| Mercury-193m | 100 |
| Mercury-193 | 1,000 |
| Mercury-194 | 1 |
| Mercury-195m | 100 |
| Mercury-195 | 1,000 |
| Mercury-197m | 100 |
| Mercury-197 | 1,000 |
| Mercury-199m | 1,000 |
| Mercury-203 | 100 |

| | | | |
|---|---|---|---|
| Thallium-194m | 1,000 | Francium-223 | 100 |
| Thallium-194 | 1,000 | Radium-223 | 0.1 |
| Thallium-195 | 1,000 | Radium-224 | 0.1 |
| Thallium-197 | 1,000 | Radium-225 | 0.1 |
| Thallium-198m | 1,000 | Radium-226 | 0.1 |
| Thallium-198 | 1,000 | Radium-227 | 1,000 |
| Thallium-199 | 1,000 | Radium-228 | 0.1 |
| Thallium-200 | 1,000 | Actinium-224 | 1 |
| Thallium-201 | 1,000 | Actinium-225 | 0.01 |
| Thallium-202 | 100 | Actinium-226 | 0.1 |
| Thallium-204 | 100 | Actinium-227 | 0.001 |
| Lead-195m | 1,000 | Actinium-228 | 1 |
| Lead-198 | 1,000 | Thorium-226 | 10 |
| Lead-199 | 1,000 | Thorium-227 | 0.01 |
| Lead-200 | 100 | Thorium-228 | 0.001 |
| Lead-201 | 1,000 | Thorium-229 | 0.001 |
| Lead-202m | 1,000 | Thorium-230 | 0.001 |
| Lead-202 | 10 | Thorium-231 | 100 |
| Lead-203 | 1,000 | Thorium-232 | 100 |
| Lead-205 | 100 | Thorium-234 | 10 |
| Lead-209 | 1,000 | Thorium-natural | 100 |
| Lead-210 | 0.01 | Protactinium-227 | 10 |
| Lead-211 | 100 | Protactinium-228 | 1 |
| Lead-212 | 1 | Protactinium-230 | 0.1 |
| Lead-214 | 100 | Protactinium-231 | 0.001 |
| Bismuth-200 | 1,000 | Protactinium-232 | 1 |
| Bismuth-201 | 1,000 | Protactinium-233 | 100 |
| Bismuth-202 | 1,000 | Protactinium-234 | 100 |
| Bismuth-203 | 100 | Uranium-230 | 0.01 |
| Bismuth-205 | 100 | Uranium-231 | 100 |
| Bismuth-206 | 100 | Uranium-232 | 0.001 |
| Bismuth-207 | 10 | Uranium-233 | 0.001 |
| Bismuth-210m | 0.1 | Uranium-234 | 0.001 |
| Bismuth-210 | 1 | Uranium-235 | 0.001 |
| Bismuth-212 | 10 | Uranium-236 | 0.001 |
| Bismuth-213 | 10 | Uranium-237 | 100 |
| Bismuth-214 | 100 | Uranium-238 | 100 |
| Polonium-203 | 1,000 | Uranium-239 | 1,000 |
| Polonium-205 | 1,000 | Uranium-240 | 100 |
| Polonium-207 | 1,000 | Uranium-natural | 100 |
| Polonium-210 | 0.1 | Neptunium-232 | 100 |
| Astatine-207 | 100 | Neptunium-233 | 1,000 |
| Astatine-211 | 10 | Neptunium-234 | 100 |
| Radon-220 | 1 | Neptunium-235 | 100 |
| Radon-222 | 1 | Neptunium-236 | |
| Francium-222 | 100 | (1.15E+5) | 0.001 |

| | | | |
|---|---|---|---|
| Neptunium-236 (22.5h) | 1 | Curium-242 | 0.01 |
| Neptunium-237 | 0.001 | Curium-243 | 0.001 |
| Neptunium-238 | 10 | Curium-244 | 0.001 |
| Neptunium-239 | 100 | Curium-245 | 0.001 |
| Neptunium-240 | 1,000 | Curium-246 | 0.001 |
| Plutonium-234 | 10 | Curium-247 | 0.001 |
| Plutonium-235 | 1,000 | Curium-248 | 0.001 |
| Plutonium-236 | 0.001 | Curium-249 | 1,000 |
| Plutonium-237 | 100 | Berkelium-245 | 100 |
| Plutonium-238 | 0.001 | Berkelium-246 | 100 |
| Plutonium-239 | 0.001 | Berkelium-247 | 0.001 |
| Plutonium-240 | 0.001 | Berkelium-249 | 0.1 |
| Plutonium-241 | 0.01 | Berkelium-250 | 10 |
| Plutonium-242 | 0.001 | Californium-244 | 100 |
| Plutonium-243 | 1,000 | Californium-246 | 1 |
| Plutonium-244 | 0.001 | Californium-248 | 0.01 |
| Plutonium-245 | 100 | Californium-249 | 0.001 |
| Americium-237 | 1,000 | Californium-250 | 0.001 |
| Americium-238 | 100 | Californium-251 | 0.001 |
| Americium-239 | 1,000 | Californium-252 | 0.001 |
| Americium-240 | 100 | Californium-253 | 0.1 |
| Americium-241 | 0.001 | Californium-254 | 0.001 |
| Americium-242m | 0.001 | Einsteinium-250 | 100 |
| Americium-242 | 10 | Einsteinium-251 | 100 |
| Americium-243 | 0.001 | Einsteinium-253 | 0.1 |
| Americium-244m | 100 | Einsteinium-254m | 1 |
| Americium-244 | 10 | Einsteinium-254 | 0.01 |
| Americium-245 | 1,000 | Fermium-252 | 1 |
| Americium-246m | 1,000 | Fermium-253 | 1 |
| Americium-246 | 1,000 | Fermium-254 | 10 |
| Curium-238 | 100 | Fermium-255 | 1 |
| Curium-240 | 0.1 | Fermium-257 | 0.01 |
| Curium-241 | 1 | Mendelevium-257 | 10 |
| | | 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 |

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

[1]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 B to this chapter, 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.

NOTE: For purposes of 40.61(5), 40.64(1), and 40.95(1) 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.

# CHAPTER 40

## APPENDIX D

## REQUIREMENTS FOR TRANSFERS OF LOW-LEVEL RADIOACTIVE WASTE INTENDED FOR DISPOSAL AT LICENSED LAND DISPOSAL FACILITIES AND MANIFESTS

As used in this appendix, the following definitions apply:

"Chelating agent" means amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids, and polycarboxylic acids (e.g., citric acid, carbolic acid, and glucinic acid).

"Chemical description" means a description of the principal chemical characteristics of a low-level radioactive waste.

"Computer-readable medium" means that the regulatory agency's computer can transfer the information from the medium into its memory.

"Consignee" means the designated receiver of the shipment of low-level radioactive waste.

"Decontamination facility" means a facility operating under an Agreement State or Nuclear Regulatory Commission license whose principal purpose is decontamination of equipment or materials to accomplish recycle, reuse, or other waste management objectives and, for purposes of this appendix, is not considered to be a consignee for LLW shipments.

"Disposal container" means a container principally used to confine low-level radioactive waste during disposal operations at a land disposal facility (also see "high integrity container"). Note that for some shipments, the disposal container may be the transport package.

"EPA identification number" means the number received by a transporter following application to the administrator of EPA as required by 40 CFR Part 263.

"Forms 540, 540A, 541, 541A, 542, and 542A" are official forms referenced in this appendix. Licensees need not use originals of these forms as long as any substitute forms are equivalent to the original documentation in respect to content, clarity, size, and location of information. Upon agreement between the shipper and consignee, Forms 541 (and 541A) and Forms 542 (and 542A) may be completed, transmitted, and stored in electronic media. The electronic media must have the capability for producing legible, accurate, and complete records in the format of the uniform manifest.

"Generator" means a licensee operating under an Agreement State or Nuclear Regulatory Commission license who (1) is a waste generator as defined in this rule, or (2) is the licensee to whom waste can be attributed within the context of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (e.g., waste generated as a result of decontamination or recycle activities).

"High integrity container (HIC)" means a container commonly designed to meet the structural stability requirements of 10 CFR 61.56, and to meet United States Department of Transportation requirements for a Type A package.

"Land disposal facility" means the land, buildings and structures, and equipment which are intended to be used for the disposal of radioactive wastes. For purposes of this appendix, a "geologic repository" as defined in 10 CFR Part 60 is not considered a land disposal facility.

"Package" means the assembly of components necessary to ensure compliance with the packaging requirements of United States Department of Transportation regulations, together with its radioactive contents, as presented for transport.

"Physical description" means the items called for on Form 541 to describe a low-level radioactive waste.

"Residual waste" means low-level radioactive waste resulting from processing or decontamination activities that cannot be easily separated into distinct batches attributable to specific waste generators. This waste is attributable to the processor or decontamination facility, as applicable.

"Shipper" means the licensed entity (i.e., the waste generator, waste collector, or waste processor) who offers low-level radioactive waste for transportation, typically consigning this type of waste to a licensed waste collector, waste processor, or land disposal facility operator.

"Shipping paper" means Form 540 and, if required, Form 540A which includes the information required by United States Department of Transportation in 49 CFR Part 172.

"Uniform Low-Level Radioactive Waste Manifest" or "uniform manifest" means the combination of Forms 540, 541 and, if necessary, 542, and their respective continuation sheets as needed, or equivalent.

"Waste collector" means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, whose principal purpose is to collect and consolidate waste generated by others, and to transfer this waste, without processing or repackaging the collected waste, to another licensed waste collector, licensed waste processor, or licensed land disposal facility.

"Waste description" means the physical, chemical and radiological description of a low-level radioactive waste as called for on Form 541.

"Waste generator" means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, who (1) possesses any material or component that contains radioactivity or is radioactively contaminated for which the licensee foresees no further use, and (2) transfers this material or component to a licensed land disposal facility or to a licensed waste collector or processor for handling or treatment prior to disposal. A licensee performing processing or decontamination services may be a "waste generator" if the transfer of low-level radioactive waste from its facility is defined as "residual waste."

"Waste processor" means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, whose principal purpose is to process, repackage, or otherwise treat low-level radioactive material or waste generated by others prior to eventual transfer of waste to a licensed low-level radioactive waste land disposal facility.

"Waste type" means a waste within a disposal container having a unique physical description (i.e., a specific waste descriptor code or description; or a waste sorbed on or solidified in a specifically defined media).

I. Manifest

A waste generator, collector, or processor who transports, or offers for transportation, low-level radioactive waste intended for ultimate disposal at a licensed low-level radioactive waste land disposal facility must prepare a manifest reflecting information requested on applicable Forms 540 (Uniform Low-Level Radioactive Waste Manifest (Shipping Paper)) and 541 (Uniform Low-Level Radioactive Waste Manifest (Container and Waste Description)) and, if necessary, on an applicable Form 542 (Uniform Low-Level Radioactive Waste Manifest (Manifest Index and Regional Compact Tabulation)). Forms 540 and 540A must be completed and must physically accompany the pertinent low-level waste shipment. Upon agreement between shipper and consignee, Forms 541 and 541A and 542 and 542A may be completed, transmitted, and stored in electronic media with the capability for producing legible, accurate, and complete records on the respective forms. Licensees are not required by this agency to comply with the manifesting requirements of this part when they ship:

(a) LLW for processing and expect its return (i.e., for storage under their license) prior to disposal at a licensed land disposal facility;

(b) LLW that is being returned to the licensee who is the "waste generator" or "generator," as defined in this part; or

(c) Radioactively contaminated material to a "waste processor" that becomes the processor's "residual waste."

For guidance in completing these forms, refer to the instructions that accompany the forms. Copies of manifests required by this appendix may be legible carbon copies, photocopies, or computer printouts that reproduce the data in the format of the uniform manifest.

Forms 540, 540A, 541, 541A, 542 and 542A, and the accompanying instructions, in hard copy, may be obtained from the Information and Records Management Branch, Office of Information Resources Management, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301) 415-7232.

This appendix includes information requirements of the United States Department of Transportation, as codified in 49 CFR Part 172. Information on hazardous, medical, or other waste required to meet Environmental Protection Agency regulations, as codified in 40 CFR Parts 259, 261, or elsewhere, is not addressed in this section, and must be provided on the required EPA forms. However, the required EPA forms must accompany the Uniform Low-Level Radioactive Waste Manifest required by this chapter.

Information Requirements

A. General Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest:

1. The name, facility's address, and telephone number of the licensee shipping the waste;
2. An explicit declaration indicating whether the shipper is acting as a waste generator, collector, processor, or a combination of these identifiers for purposes of the manifested shipment; and
3. The name, address, and telephone number, or the name and EPA identification number, for the carrier transporting the waste.

B. Shipment Information

The shipper of the radioactive waste shall provide the following information regarding the waste shipment on the uniform manifest:

1. The date of the waste shipment;
2. The total number of packages/disposal containers;
3. The total disposal volume and disposal weight in the shipment;
4. The total radionuclide activity in the shipment;
5. The activity of each of the radionuclides, H-3, C-14, Tc-99, and I-129 contained in the shipment; and
6. The total masses of U-233, U-235, and plutonium in special nuclear material, and the total mass of uranium and thorium in source material.

C. Disposal Container and Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding the waste and each disposal container of waste in the shipment:

1. An alphabetic or numeric identification that uniquely identifies each disposal container in the shipment;
2. A physical description of the disposal container, including the manufacturer and model of any high integrity container;
3. The volume displaced by the disposal container;
4. The gross weight of the disposal container, including the waste;
5. For waste consigned to a disposal facility, the maximum radiation level at the surface of each disposal container;
6. A physical and chemical description of the waste;
7. The total weight percentage of chelating agent for any waste containing more than 0.1 percent chelating agent by weight, plus the identity of the principal chelating agent;

8. The approximate volume of waste within a container;

9. The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name;

10. The identities and activities of individual radionuclides contained in each container, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material. For discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides associated with or contained in these waste types within a disposal container shall be reported;

11. The total radioactivity within each container; and

12. For wastes consigned to a disposal facility, the classification of the waste pursuant to 10 CFR 61.55. Waste not meeting the structural stability requirements of 10 CFR 61.56(b) must be identified.

D. Uncontainerized Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding a waste shipment delivered without a disposal container:

1. The approximate volume and weight of the waste;

2. A physical and chemical description of the waste;

3. The total weight percentage of chelating agent if the chelating agent exceeds 0.1 percent by weight, plus the identity of the principal chelating agent;

4. For waste consigned to a disposal facility, the classification of the waste pursuant to 10 CFR 61.55. Waste not meeting the structural stability requirements of 10 CFR 61.56(b) must be identified;

5. The identities and activities of individual radionuclides contained in the waste, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material; and

6. For wastes consigned to a disposal facility, the maximum radiation levels at the surface of the waste.

E. Multigenerator Disposal Container Information

This section applies to disposal containers enclosing mixtures of waste originating from different generators. (Note: The origin of the LLW resulting from a processor's activities may be attributable to one or more "generators" (including "waste generators") as defined in this appendix.) It also applies to mixtures of wastes shipped in an uncontainerized form, for which portions of the mixture within the shipment originate from different generators.

1. For homogeneous mixtures of waste, such as incinerator ash, provide the waste description applicable to the mixture and the volume of the waste attributed to each generator.

2. For heterogeneous mixtures of waste, such as the combined products from a large compactor, identify each generator contributing waste to the disposal container and, for discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides contained in these waste types within the disposal container. For each generator, provide the following:

(a) The volume of waste within the disposal container;

(b) A physical and chemical description of the waste, including the solidification agent, if any;

(c) The total weight percentage of chelating agents for any disposal container containing more than 0.1 percent chelating agent by weight, plus the identity of the principal chelating agent;

(d) The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name if the media is claimed to meet stability requirements in 10 CFR 61.56(b); and

(e) Radionuclide identities and activities contained in the waste, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material if contained in the waste.

II. Certification

An authorized representative of the waste generator, processor, or collector shall certify by signing and dating the shipment manifest that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the United States Department of Transportation and this agency. A collector in signing the certification is certifying that nothing has been done to the collected waste that would invalidate the waste generator's certification.

III. Control and Tracking

A. Any licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1. through A.9. of this appendix. Any licensee who transfers waste to a licensed waste processor for waste treatment or repackaging shall comply with the requirements of paragraphs A.4. through A.9. of this appendix. A licensee shall:

1. Prepare all wastes so that the waste is classified according to 10 CFR 61.55 and meets the waste characteristics requirements in 10 CFR 61.56;

2. Label each disposal container (or transport package if potential radiation hazards preclude labeling of the individual disposal container) of waste to identify whether it is Class A waste, Class B waste, Class C waste, or greater than Class C waste, in accordance with 10 CFR 61.55;

3. Conduct a quality assurance program to ensure compliance with 10 CFR 61.55 and 61.56 (the program must include management evaluation of audits);

4. Prepare the Uniform Low-Level Radioactive Waste Manifest as required by this appendix;

5. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either (1) receipt of the manifest precedes the LLW shipment or (2) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

6. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph A.5. of this section;

7. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;

8. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41); and

9. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Form 540;

2. Prepare a new manifest to reflect consolidated shipments that meet the requirements of this appendix. The waste collector shall ensure that, for each container of waste in the shipment, the manifest identifies the generator of that container of waste;

3. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either: (1) receipt of the manifest precedes the LLW shipment or (2) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

4. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph B.3. of this section;

5. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;

6. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41);

7. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix; and

8. Notify the shipper and this agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.

C. Any licensed waste processor who treats or repackages waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Form 540;

2. Prepare a new manifest that meets the requirements of this appendix. Preparation of the new manifest reflects that the processor is responsible for meeting these requirements. For each container of waste in the shipment, the manifest shall identify the waste generators, the preprocessed waste volume, and the other information as required in paragraph E.1. of this appendix;

3. Prepare all wastes so that the waste is classified according to 10 CFR 61.55 and meets the waste characteristics requirements in 10 CFR 61.56;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with 10 CFR 61.55 and 61.57;

5. Conduct a quality assurance program to ensure compliance with 10 CFR 61.55 and 61.56 (the program shall include management evaluation of audits);

6. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either (1) receipt of the manifest precedes the LLW shipment or (2) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

7. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph C.6. of this section;

8. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;

9. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41);

10. For any shipment or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix; and

11. Notify the shipper and this agency of any shipment, or part of a shipment, that has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within one week of receipt by returning, as a minimum, a signed copy of Form 540 to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. If any discrepancy exists between materials listed on the Uniform Low-Level Radioactive Waste Manifest and materials received, copies or electronic transfer of the affected forms must be returned indicating the discrepancy;

2. Maintain copies of all completed manifests and electronically store the information required by 10 CFR 61.80(l) until the license is terminated; and

3. Notify the shipper and this agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.

E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and

2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with this agency. Each licensee who conducts a trace investigation shall file a written report with this agency within two weeks of completion of the investigation.

# CHAPTER 40

## APPENDIX E

## CLASSIFICATION AND CHARACTERISTICS OF LOW-LEVEL RADIOACTIVE WASTE

### I. Classification of Radioactive Waste for Land Disposal

a) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

b) Classes of waste.

1) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in Section II. (a). If Class A waste also meets the stability requirements set forth in Section II. (b), it is not necessary to segregate the waste for disposal.

2) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in Section II.

3) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in Section II.

c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table I, classification shall be determined as follows:

1) If the concentration does not exceed 0.1 times the value in Table I, the waste is Class A.

2) If the concentration exceeds 0.1 times the value in Table I, but does not exceed the value in Table I, the waste is Class C.

3) If the concentration exceeds the value in Table I, the waste is not generally acceptable for land disposal.

4) For wastes containing mixtures of radionuclides listed in Table I, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE I

| Radionuclide | Concentration curie/cubic meter[a] | nanocurie/gram[b] |
|---|---|---|
| C-14 | 8 | |
| C-14 in activated metal | 80 | |
| Ni-59 in activated metal | 220 | |
| Nb-94 in activated metal | 0.2 | |
| Tc-99 | 3 | |
| I-129 | 0.08 | |
| Alpha emitting transuranic radionuclides with half-life greater than five years | | 100 |
| Pu-241 | | 3,500 |
| Cm-242 | | 20,000 |
| Ra-226 | | 100 |

[a] To convert the Ci/$m^3$ values to gigabecquerel (GBq) per cubic meter, multiply the Ci/$m^3$ value by 37.
[b] To convert the nCi/g values to becquerel (Bq) per gram, multiply the nCi/g value by 37.

d) Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table I, classification shall be determined based on the concentrations shown in Table II. However, as specified in Section I.(f), if radioactive waste does not contain any nuclides listed in either Table I or II, it is Class A.

1) If the concentration does not exceed the value in Column 1, the waste is Class A.

2) If the concentration exceeds the value in Column 1 but does not exceed the value in Column 2, the waste is Class B.

3) If the concentration exceeds the value in Column 2 but does not exceed the value in Column 3, the waste is Class C.

4) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

5) For wastes containing mixtures of the radionuclides listed in Table II, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE II

| Radionuclide | Concentration, Column 1 | curie/cubic meter * Column 2 | Column 3 |
|---|---|---|---|
| Total of all radio-nuclides with less than 5-year half-life | 700 | * | * |
| H-3 | 40 | * | * |
| Co-60 | 700 | * | * |
| Ni-63 | 3.5 | 70 | 700 |
| Ni-63 in activated metal | 35 | 700 | 7000 |
| Sr-90 | 0.04 | 150 | 7000 |
| Cs-137 | 1 | 44 | 4600 |

*AGENCY NOTE: To convert the Ci/$m^3$ value to gigabecquerel (GBq) per cubic meter, multiply the Ci/$m^3$ value by 37. There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other radionuclides in Table II determine the waste to be Class C independent of these radionuclides.

e) Classification determined by both long- and short-lived radionuclides. If the radioactive waste contains a mixture of radionuclides, some of which are listed in Table I and some of which are listed in Table II, classification shall be determined as follows:

1) If the concentration of a radionuclide listed in Table I is less than 0.1 times the value listed in Table I, the class shall be that determined by the concentration of radionuclides listed in Table II.

2) If the concentration of a radionuclide listed in Table I exceeds 0.1 times the value listed in Table I, but does not exceed the value in Table I, the waste shall be Class C, provided the concentration of radionuclides listed in Table II does not exceed the value shown in Column 3 of Table II.

f) Classification of wastes with radionuclides other than those listed in Tables I and II. If the waste does not contain any radionuclides listed in either Table I or II, it is Class A.

g) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as becquerel (nanocurie) per gram.

h) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 1.85 TBq/$m^3$ (50 Ci/$m^3$) and Cs-137 in a concentration of 814 GBq/$m^3$ (22 Ci/$m^3$). Since the concentrations both exceed the values in Column 1, Table II, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33; for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

II. Radioactive Waste Characteristics

a) The following are minimum requirements for all classes of waste and are intended to facilitate handling and provide protection of health and safety of personnel at the disposal site.

1) Wastes shall be packaged in conformance with the conditions of the license issued to the site operator to which the waste will be shipped. Where the conditions of the site license are more restrictive than the provisions of this chapter, the site license conditions shall govern.

2) Wastes shall not be packaged for disposal in cardboard or fiberboard boxes.

3) Liquid waste shall be packaged in sufficient absorbent material to absorb twice the volume of the liquid.

4) Solid waste containing liquid shall contain as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

5) Waste shall not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

6) Waste shall not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with Section II.(a)(8).

7) Waste must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.[4]

8) Wastes in a gaseous form shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at 20°C. Total activity shall not exceed 100 Ci (3.7 TBq) per container.

[4]See 641—38.2 of these rules for the definition of pyrophoric.

9) Wastes containing hazardous, biological, pathogenic, or infectious material shall be treated to reduce to the maximum extent practicable the potential hazard from the nonradiological materials.

b) The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

1) Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

2) Notwithstanding the provisions in Section II.(a)(3) and (4), liquid wastes, or wastes containing liquid, shall be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.

3) Void spaces within the waste and between the waste and its package shall be reduced to the extent practicable.

III. Labeling

Each package of waste shall be clearly labeled to identify whether it is Class A, Class B, or Class C waste, in accordance with Section I.

CHAPTER 40

APPENDIX F
QUANTITIES FOR USE WITH DECOMMISSIONING

| Material | Microcurie* |
|---|---|
| Americium-241 | 0.01 |
| Antimony-122 | 100 |
| Antimony-124 | 10 |
| Antimony-125 | 10 |
| Arsenic-73 | 100 |
| Arsenic-74 | 10 |
| Arsenic-76 | 10 |
| Arsenic-77 | 100 |
| Barium-131 | 10 |
| Barium-133 | 10 |
| Barium-140 | 10 |
| Bismuth-210 | 1 |
| Bromine-82 | 10 |
| Cadmium-109 | 10 |
| Cadmium-115m | 10 |
| Cadmium-115 | 100 |
| Calcium-45 | 10 |
| Calcium-47 | 10 |
| Carbon-14 | 100 |
| Cerium-141 | 100 |
| Cerium-143 | 100 |
| Cerium-144 | 1 |
| Cesium-131 | 1,000 |
| Cesium-134m | 100 |
| Cesium-134 | 1 |
| Cesium-135 | 10 |
| Cesium-136 | 10 |
| Cesium-137 | 10 |
| Chlorine-36 | 10 |
| Chlorine-38 | 10 |
| Chromium-51 | 1,000 |
| Cobalt-58m | 10 |
| Cobalt-58 | 10 |
| Cobalt-60 | 1 |
| Copper-64 | 100 |
| Dysprosium-165 | 10 |
| Dysprosium-166 | 100 |
| Erbium-169 | 100 |
| Erbium-171 | 100 |
| Europium-152 (9.2 h) | 100 |
| Europium-152 (13 yr) | 1 |

| Material | Microcurie* |
|---|---|
| Europium-154 | 1 |
| Europium-155 | 10 |
| Florine-18 | 1,000 |
| Gadolinium-153 | 10 |
| Gadolinium-159 | 100 |
| Gallium-72 | 10 |
| Germanium-71 | 100 |
| Gold-198 | 100 |
| Gold-199 | 100 |
| Hafnium-181 | 10 |
| Holmium-166 | 100 |
| Hydrogen-3 | 1,000 |
| Indium-113m | 100 |
| Indium-114m | 10 |
| Indium-115m | 100 |
| Indium-115 | 10 |
| Iodine-125 | 1 |
| Iodine-126 | 1 |
| Iodine-129 | 0.1 |
| Iodine-131 | 1 |
| Iodine-132 | 10 |
| Iodine-133 | 1 |
| Iodine-134 | 10 |
| Iodine-135 | 10 |
| Iridium-192 | 10 |
| Iridium-194 | 100 |
| Iron-55 | 100 |
| Iron-59 | 10 |
| Krypton-85 | 100 |
| Krypton-87 | 10 |
| Lanthanum-140 | 10 |
| Lutetium-177 | 100 |
| Manganese-52 | 10 |
| Manganese-54 | 10 |
| Manganese-56 | 10 |
| Mercury-197m | 100 |
| Mercury-197 | 100 |
| Mercury-203 | 10 |
| Molybdenum-99 | 100 |
| Neodymium-147 | 100 |
| Neodymium-149 | 100 |
| Nickel-59 | 100 |
| Nickel-63 | 10 |
| Nickel-65 | 100 |

| Material | Microcurie* |
|---|---|
| Niobium-93m | 10 |
| Niobium-95 | 10 |
| Niobium-97 | 10 |
| Osmium-185 | 10 |
| Osmium-191m | 100 |
| Osmium-191 | 100 |
| Osmium-193 | 100 |
| Palladium-103 | 100 |
| Palladium-109 | 100 |
| Phosphorus-32 | 10 |
| Platinum-191 | 100 |
| Platinum-193m | 100 |
| Platinum-193 | 100 |
| Platinum-197m | 100 |
| Platinum-197 | 100 |
| Plutonium-239 | 0.01 |
| Polonium-210 | 0.1 |
| Potassium-42 | 10 |
| Praseodymium-142 | 100 |
| Praseodymium-143 | 100 |
| Promethium-147 | 10 |
| Promethium-149 | 10 |
| Radium-226 | 0.01 |
| Rhenium-186 | 100 |
| Rhenium-188 | 100 |
| Rhodium-103m | 100 |
| Rhodium-105 | 100 |
| Rubidium-86 | 10 |
| Rubidium-87 | 10 |
| Ruthenium-97 | 100 |
| Ruthenium-103 | 10 |
| Ruthenium-105 | 10 |
| Ruthenium-106 | 1 |
| Samarium-151 | 10 |
| Samarium-153 | 100 |
| Scandium-46 | 10 |
| Scandium-47 | 100 |
| Scandium-48 | 10 |
| Selenium-75 | 10 |
| Silicon-31 | 100 |
| Silver-105 | 10 |
| Silver-110m | 1 |
| Silver-111 | 100 |
| Sodium-22 | 1 |

| Material | Microcurie* |
|---|---|
| Sodium-24 | 10 |
| Strontium-85 | 10 |
| Strontium-89 | 1 |
| Strontium-90 | 0.1 |
| Strontium-91 | 10 |
| Strontium-92 | 10 |
| Sulfur-35 | 100 |
| Tantalum-182 | 10 |
| Technetium-96 | 10 |
| Technetium-97m | 100 |
| Technetium-97 | 100 |
| Technetium-99m | 100 |
| Technetium-99 | 10 |
| Tellurium-125m | 10 |
| Tellurium-127m | 10 |
| Tellurium-127 | 100 |
| Tellurium-129m | 10 |
| Tellurium-129 | 100 |
| Tellurium-131m | 10 |
| Tellurium-132 | 10 |
| Terbium-160 | 10 |
| Thallium-200 | 100 |
| Thallium-201 | 100 |
| Thallium-202 | 100 |
| Thallium-204 | 10 |
| Thorium (natural)** | 100 |
| Thulium-170 | 10 |
| Thulium-171 | 10 |
| Tin-113 | 10 |
| Tin-125 | 10 |
| Tungsten-181 | 10 |
| Tungsten-185 | 10 |
| Tungsten-187 | 100 |
| Uranium (natural)** | 100 |
| Uranium-233 | 0.01 |
| Uranium-234 | 0.01 |
| Uranium-235 | 0.01 |
| Vanadium-48 | 10 |
| Xenon-131m | 1,000 |
| Xenon-133 | 100 |
| Xenon-135 | 100 |
| Ytterbium-175 | 100 |
| Yttrium-90 | 10 |
| Yttrium-91 | 10 |

| Material | Microcurie* |
|---|---|
| Yttrium-92 | 100 |
| Yttrium-93 | 100 |
| Zinc-65 | 10 |
| Zinc-69m | 100 |
| Zinc-69 | 1,000 |
| Zirconium-93 | 10 |
| Zirconium-95 | 10 |
| Zirconium-97 | 10 |
| Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition | 0.01 |
| Any radionuclide other than alpha-emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition | 0.1 |

*To convert μCi to kBq, multiply the μCi value by 37.
**Based on alpha disintegration rate of U-238, U-234, and U-235.

NOTE: This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the U.S. Nuclear Regulatory Commission.

NOTE: Where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1"—that is, unity.

These rules are intended to implement Iowa Code chapter 136C.

[Filed 4/7/80, Notice 2/6/80—published 4/30/80, effective 7/1/80]
[Filed 5/17/85, Notice 2/27/85—published 6/5/85, effective, see rule 40.24]
[Filed 11/24/86, Notice 10/8/86—published 12/17/86, effective 1/21/87]
[Filed 11/6/87, Notice 9/23/87—published 12/2/87, effective 1/6/88]
[Filed 5/10/91, Notice 4/3/91—published 5/29/91, effective 8/28/91]
[Filed 7/16/92, Notice 5/27/92—published 8/5/92, effective 9/9/92]
[Filed 11/5/92, Notice 9/30/92—published 11/25/92, effective 1/13/93]
[Filed 9/17/93, Notice 8/4/93—published 10/13/93, effective 1/1/94]
[Filed 7/14/94, Notice 6/8/94—published 8/3/94, effective 9/7/94]
[Filed 5/15/95, Notice 3/29/95—published 6/7/95, effective 7/12/95]
[Filed 9/16/96, Notice 7/17/96—published 10/9/96, effective 11/16/96]
[Filed 5/16/97, Notice 4/9/97—published 6/4/97, effective 7/9/97]
[Filed 3/18/98, Notice 1/14/98—published 4/8/98, effective 7/1/98]
[Filed 4/2/99, Notice 1/13/99—published 4/21/99, effective 7/1/99]
[Filed 3/15/00, Notice 1/26/00—published 4/5/00, effective 5/10/00]