

Research and Special Programs Admin., DOT

§ 173.434

daughter nuclides will be considered as a mixture of different nuclides.

(d) Mixtures of radionuclides whose identities and respective activities are known, must conform to the following conditions:

(1) For special form Class 7 (radioactive) material:

$$\sum_i \frac{B(i)}{A_1(i)} \text{ less than or equal to } 1$$

Where $B(i)$ is the activity of radionuclide i and $A_1(i)$ is the A_1 value for radionuclide i ;

or

(2) For other forms of Class 7 (radioactive) material, either—

$$\sum_i \frac{B(i)}{A_2(i)} \text{ less than or equal to } 1$$

Where $B(i)$ is the activity of radionuclide i and $A_2(i)$ is the A_2 value for radionuclide i ;

or

$$A_2 \text{ for mixture} = \frac{1}{\sum_i \frac{f(i)}{A_2(i)}}$$

where $f(i)$ is the fraction of activity of nuclide i in the mixture and $A_2(i)$ is the appropriate A_2 value for nuclide i .

(e) When the identity of each nuclide is known but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph (d) of this section. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest A_1 or A_2 values for the alpha emitters or beta/gamma emitters, respectively.

(f) *Shipping papers and labeling.* (1) For mixtures of radionuclides, the radionuclides (n) that must be shown on shipping papers and labels in accordance with §§ 172.203 and 172.403 of this subchapter, respectively, must be determined on the basis of the following formula:

$$\sum_{i=1}^n \frac{a_{(i)}}{A_{(i)}} \geq 0.95 \sum_{i=1}^{n+m} \frac{a_{(i)}}{A_{(i)}}$$

Where $n + m$ represents all the radionuclides in the mixture, m are the radionuclides that do not need to be considered, $a_{(i)}$ is the activity of radionuclide i in the mixture, and $A_{(i)}$ is the A_1 or A_2 value, as appropriate for radionuclide i .

(g) Table 10 is as follows:

TABLE 10—GENERAL VALUES FOR A_1 AND A_2

| Contents | A_1 | | A_2 | |
|---|-------|------|--------------------|-----------------------|
| | (TBq) | (Ci) | (TBq) | (Ci) |
| Only beta or gamma emitting nuclides are known to be present | 0.2 | 5 | 0.02 | 0.5 |
| Alpha emitting nuclides are known to be present or no relevant data are available | 0.10 | 2.70 | 2×10^{-5} | 5.41×10^{-4} |

[Amdt. 173-244, 60 FR 50307, Sept. 28, 1995, as amended at 63 FR 52849, Oct. 1, 1998; 66 FR 45184, 45379, Aug. 28, 2001]

§ 173.434 Activity-mass relationships for uranium and natural thorium.

The table of activity-mass relationships for uranium and natural thorium are as follows:

| Thorium and uranium enrichment ¹ (Wt% ^{235}U present) | Specific activity | | | |
|--|----------------------|-------------------|----------------------|-------------------|
| | TBq/gram | Grams/Tbq | Ci/gram | Grams/Ci |
| 0.45 (depleted) | 1.9×10^{-8} | 5.4×10^7 | 5.0×10^{-7} | 2.0×10^6 |
| 0.72 (natural) | 2.6×10^{-8} | 3.8×10^7 | 7.1×10^{-7} | 1.4×10^6 |
| 1.0 | 2.8×10^{-8} | 3.6×10^7 | 7.6×10^{-7} | 1.3×10^6 |
| 1.5 | 3.7×10^{-8} | 2.7×10^7 | 1.0×10^{-6} | 1.0×10^6 |
| 5.0 | 1.0×10^{-7} | 1.0×10^7 | 2.7×10^{-6} | 3.7×10^5 |

§ 173.435

49 CFR Ch. I (10-1-01 Edition)

| Thorium and uranium enrichment ¹ (Wt% ^{235}U present) | Specific activity | | | |
|--|----------------------|-------------------|----------------------|-------------------|
| | TBq/gram | Grams/Tbq | Ci/gram | Grams/Ci |
| 10.0 | 1.8×10^{-7} | 5.6×10^6 | 4.8×10^{-6} | 2.1×10^5 |
| 20.0 | 3.7×10^{-7} | 2.7×10^6 | 1.0×10^{-5} | 1.0×10^5 |
| 35.0 | 7.4×10^{-7} | 1.4×10^6 | 2.0×10^{-5} | 5.0×10^4 |
| 50.0 | 9.3×10^{-7} | 1.1×10^6 | 2.5×10^{-5} | 4.0×10^4 |
| 90.0 | 2.1×10^{-6} | 4.7×10^5 | 5.8×10^{-5} | 1.7×10^4 |
| 93.0 | 2.6×10^{-6} | 3.9×10^5 | 7.0×10^{-5} | 1.4×10^4 |
| 95.0 | 3.4×10^{-6} | 3.0×10^5 | 9.1×10^{-5} | 1.1×10^4 |
| Natural thorium | 8.1×10^{-9} | 1.2×10^8 | 2.2×10^{-7} | 4.6×10^6 |

¹The figures for uranium include representative values for the activity of uranium-234 which is concentrated during the enrichment process. The activity for thorium includes the equilibrium concentration of thorium-228.

[Amdt. 173-244, 60 FR 50307, Sept. 28, 1995, as amended by 63 FR 52849, Oct. 1, 1998]

§ 173.435 Table of A₁ and A₂ values for radionuclides.

The table of A₁ and A₂ values for radionuclides is as follows:

| Symbol of radio-nuclide | Element and atomic number | A ₁ (TBq) | A ₁ (Ci) | A ₂ (TBq) | A ₂ (Ci) | Specific activity | |
|-------------------------|---------------------------|----------------------|---------------------|----------------------|-----------------------|----------------------|----------------------|
| | | | | | | (TBq/g) | (Ci/g) |
| Ac-225 | Actinium(89) | 0.6 | 16.2 | 1×10^{-2} | 0.270 | 2.1×10^3 | 5.8×10^4 |
| Ac-227 | | 40 | 1080 | 2×10^{-5} | 5.41×10^{-4} | 2.7 | 7.2×10^1 |
| Ac-228 | | 0.6 | 16.2 | 0.4 | 10.8 | 8.4×10^4 | 2.2×10^6 |
| Ag-105 | Silver(47) | 2 | 54.1 | 2 | 54.1 | 1.1×10^3 | 3.0×10^4 |
| Ag-108m | | 0.6 | 16.2 | 0.6 | 16.2 | 9.7×10^{-1} | 2.6×10^1 |
| Ag-110m | | 0.4 | 10.8 | 0.4 | 10.8 | 1.8×10^2 | 4.7×10^3 |
| Ag-111 | | 0.6 | 16.2 | 0.5 | 13.5 | 5.8×10^3 | 1.6×10^5 |
| Al-26 | Aluminum(13) | 0.4 | 10.8 | 0.4 | 10.8 | 7.0×10^{-4} | 1.9×10^{-2} |
| Am-241 | Americium(95) | 2 | 54.1 | 2×10^{-4} | 5.41×10^{-3} | 1.3×10^{-1} | 3.4 |
| Am-242m | | 2 | 54.1 | 2×10^{-4} | 5.41×10^{-3} | 3.6×10^{-1} | 1.0×10^1 |
| Am-243 ... | | 2 | 54.1 | 2×10^{-4} | 5.41×10^{-3} | 7.4×10^{-3} | 2.0×10^{-1} |
| Ar-37 | Argon(18) | 40 | 1080 | 40 | 1080 | 3.7×10^3 | 9.9×10^4 |
| Ar-39 | | 20 | 54.1 | 20 | 54.1 | 1.3 | 3.4×10^1 |
| Ar-41 | | 0.6 | 16.2 | 0.6 | 16.2 | 1.5×10^6 | 4.2×10^7 |
| Ar-42 | | 0.2 | 5.41 | 0.2 | 5.41 | 9.6 | 2.6×10^2 |
| As-72 | Arsenic(33) | 0.2 | 5.41 | 0.2 | 5.41 | 6.2×10^4 | 1.7×10^6 |
| As-73 | | 40 | 1080 | 40 | 1080 | 8.2×10^2 | 2.2×10^4 |
| As-74 | | 1 | 27.0 | 0.5 | 13.5 | 3.7×10^3 | 9.9×10^4 |
| As-76 | | 0.2 | 5.41 | 0.2 | 5.41 | 5.8×10^4 | 1.6×10^6 |
| As-77 | | 20 | 54.1 | 0.5 | 13.5 | 3.9×10^4 | 1.0×10^6 |
| At-211 | Astatine(85) | 30 | 811 | 2 | 54.1 | 7.6×10^4 | 2.1×10^6 |
| Au-193 | Gold(79) | 6 | 162 | 6 | 162 | 3.4×10^4 | 9.2×10^5 |
| Au-194 | | 1 | 27.0 | 1 | 27.0 | 1.5×10^4 | 4.1×10^5 |
| Au-195 | | 10 | 270 | 10 | 270 | 1.4×10^2 | 3.7×10^3 |
| Au-196 | | 2 | 54.1 | 2 | 54.1 | 4.0×10^3 | 1.1×10^5 |
| Au-198 | | 3 | 81.1 | 0.5 | 13.5 | 9.0×10^3 | 2.4×10^5 |
| Au-199 | | 10 | 270 | 0.9 | 24.3 | 7.7×10^3 | 2.1×10^5 |
| Ba-131 | Barium(56) | 2 | 54.1 | 2 | 54.1 | 3.1×10^3 | 8.4×10^4 |
| Ba-133m | | 10 | 270 | 0.9 | 24.3 | 2.2×10^4 | 6.1×10^5 |
| Ba-133 | | 3 | 81.1 | 3 | 81.1 | 9.4 | 2.6×10^2 |
| Ba-140 | | 0.4 | 10.8 | 0.4 | 10.8 | 2.7×10^3 | 7.3×10^4 |
| Be-7 | Beryllium(4) | 20 | 54.1 | 20 | 54.1 | 1.3×10^4 | 3.5×10^5 |
| Be-10 | | 20 | 54.1 | 0.5 | 13.5 | 8.3×10^{-4} | 2.2×10^{-2} |
| Bi-205 | Bismuth(83) | 0.6 | 16.2 | 0.6 | 16.2 | 1.5×10^3 | 4.2×10^4 |
| Bi-206 | | 0.3 | 8.11 | 0.3 | 8.11 | 3.8×10^3 | 1.0×10^5 |
| Bi-207 | | 0.7 | 18.9 | 0.7 | 18.9 | 1.9 | 5.2×10^1 |
| Bi-210m | | 0.3 | 8.11 | 3×10^{-2} | 0.811 | 2.1×10^{-5} | 5.7×10^{-4} |
| Bi-210 | | 0.6 | 16.2 | 0.5 | 13.5 | 4.6×10^3 | 1.2×10^5 |
| Bi-212 | | 0.3 | 8.11 | 0.3 | 8.11 | 5.4×10^5 | 1.5×10^7 |
| Bk-247 | Berkelium(97) | 2 | 54.1 | 2×10^{-4} | 5.41×10^{-3} | 3.8×10^{-2} | 1.0 |
| Bk-249 | | 40 | 1080 | 8×10^{-2} | 2.16 | 6.1×10^1 | 1.6×10^3 |
| Br-76 | Bromine(35) | 0.3 | 8.11 | 0.3 | 8.11 | 9.4×10^4 | 2.5×10^6 |
| Br-77 | | 3 | 81.1 | 3 | 81.1 | 2.6×10^4 | 7.1×10^5 |
| Br-82 | | 0.4 | 10.8 | 0.4 | 10.8 | 4.0×10^4 | 1.1×10^6 |
| C-11 | Carbon(6) | 1 | 27 | 0.5 | 13.5 | 3.1×10^7 | 8.4×10^8 |
| C-14 | | 40 | 1080 | 2 | 54.1 | 1.6×10^{-1} | 4.5 |
| Ca-41 | Calcium(20) | 40 | 1080 | 40 | 1080 | 3.1×10^{-3} | 8.5×10^{-2} |
| Ca-45 | | 40 | 1080 | 0.9 | 24.3 | 6.6×10^2 | 1.8×10^4 |