4731.0423 DETERMINATION OF A_1 AND A_2.

Subpart 1. **Generally.** Values of A_1 and A_2 for individual radionuclides, which are the bases for many activity limits elsewhere in this chapter, are given in part 4731.0422, subpart 1a. The curie (Ci) values specified are obtained by converting from the Terabecquerel (TBq) values. The Terabecquerel values are the regulatory standard. The curie values are for information only and are not intended to be the regulatory standard. Where values of A_1 and A_2 are unlimited, it is for radiation control purposes only. For nuclear criticality safety, some materials are subject to controls placed on fissile material.

Subp. 2. **Individual radionuclides; not listed in part 4731.0422, subpart 1a.** For individual radionuclides whose identities are known, but which are not listed in part 4731.0422, subpart 1a, the A_1 and A_2 values contained in subpart 6 may be used. Otherwise, the licensee shall obtain prior commissioner, NRC, or agreement state approval of the radionuclides not listed in part 4731.0422, subpart 1a, before shipping the material.

Subp. 2a. **Individual radionuclides; not listed in part 4731.0422, subpart 3.** For individual radionuclides whose identities are known, but which are not listed in part 4731.0422, subpart 3, the exempt material activity concentration and exempt consignment activity values contained in subpart 6 may be used. Otherwise, the licensee shall obtain prior commissioner, NRC, or agreement state approval of the exempt material activity concentration and exempt consignment activity values for radionuclides not listed in part 4731.0422, subpart 3, before shipping the material.

Subp. 2b. **Prior approval.** The licensee must submit requests for prior approval, described under subparts 2 and 2a, to the commissioner, NRC, or agreement state, according to this chapter.

Subp. 3. **Radioactive decay chain.** In the calculations of A_1 and A_2 for a radionuclide not in part 4731.0422, subpart 1a, a single radioactive decay chain, in which radionuclides are present in their naturally occurring proportions and in which no daughter nuclide has a half-life longer than ten days or longer than that of the parent nuclide, shall be considered as a single radionuclide. The activity to be taken into account and the A_1 and A_2 value to be applied shall be those corresponding to the parent nuclide of the chain. In the case of radioactive decay chains in which any daughter nuclide has a half-life longer than ten days or greater than that of the parent radionuclide, the parent and those daughter radionuclides shall be considered as mixtures of different radionuclides.

Subp. 4. **Radionuclide mixture.** For mixtures of radionuclides whose identities and respective activities are known, the following conditions apply:

A. For special form radioactive material, the maximum quantity transported in a Type A package:

$$\sum_i \frac{\mathrm{B}\,(\mathrm{i})}{\mathrm{A}_1\,(\mathrm{i})} \leq 1$$

where B(i) is the activity of radionuclide i in special form and A_1(i) is the A_1 value for radionuclide i.

B. For normal form radioactive material, the maximum quantity transported in a Type A package:

$$\sum_i \frac{\mathrm{B}\,(\mathrm{i})}{\mathrm{A}_2\,(\mathrm{i})} \leq 1$$

where B(i) is the activity of radionuclide i in normal form and A_2(i) is the A_2 value for radionuclide i.

C. If the package contains both a special and normal form radioactive material, the activity that may be transported in a Type A package:

$$\sum_i \frac{B(i)}{A_1(\mathrm{i})} + \sum_j \frac{C(j)}{A_2(j)} \leq 1$$

where B(i) is the activity of radionuclide i in special form, A_1(i) is the A_1 value for radionuclide i, C(j) is the activity of radionuclide j in normal form, and A_2(j) is the A_2 value for radionuclide j.

D. Alternatively, an A_1 value for mixtures of special form material may be determined as follows:

$$\mathrm{A}_1 \text{ for mixture} = \frac{1}{\sum_i \frac{\mathrm{f(i)}}{\mathrm{A}_1\mathrm{(i)}}}$$

where f(i) is the fraction of activity of radionuclide i in the mixture and A_1(i) is the appropriate A_1 value for radionuclide i.

E. Alternatively, the A_2 value for mixtures of normal form material may be determined as follows:

$$\mathrm{A}_2 \text{ for mixture} = \frac{1}{\sum_i \frac{\mathrm{f(i)}}{\mathrm{A}_2\mathrm{(i)}}}$$

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

F. The exempt activity concentration for mixtures of radionuclides may be determined as follows:

$$\text{Exempt activity concentration for mixture} = \frac{1}{\sum_i \frac{\mathrm{f(i)}}{[\mathrm{A}]\mathrm{(i)}}}$$

where f(i) is the fraction of activity concentration of radionuclide i in the mixture, and [A] (i) is the activity concentration for exempt material containing radionuclide i.

G. The activity limit for an exempt consignment for mixtures of radionuclides may be determined as follows:

$$\text{Exempt consignment activity limit for mixture} = \frac{1}{\sum_i \frac{\text{f(i)}}{\text{A(i)}}}$$

where f(i) is the fraction of activity of radionuclide i in the mixture, and A (i) is the activity limit for exempt consignments for radionuclide i.

Subp. 5. **Activities unknown.**

A. When the identity of each radionuclide 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 subpart 4. 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 and beta/gamma emitters.

B. When the identity of each radionuclide is known but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest [A] (activity concentration for exempt material) or A (activity limit for exempt consignment) value, as appropriate, for the radionuclides in each group may be used in applying the formulas in subpart 4. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest [A] or A values for the alpha emitters and beta/gamma emitters, respectively.

Subp. 6. **General values for A_1 and A_2.**

	A_1		A_2	
Contents	(TBq)	(Ci)	(TBq)	(Ci)
Only beta- or gamma-emitting radionuclides are known to be present	1×10^{-1}	2.7	2×10^{-2}	5.4×10^{-1}
Alpha-emitting nuclides, but no neutron emitters are known to be present[a]	2×10^{-1}	5.4	9×10^{-5}	2.4×10^{-3}
Neutron-emitting nuclides are known to be present or no relevant data are available	1×10^{-3}	2.7×10^{-2}	9×10^{-5}	2.4×10^{-3}

[a] If beta- or gamma-emitting nuclides are known to be present, the A_1 value of 0.1TBq (2.7 Ci) should be used.

Contents	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limits for exempt consignments (Bq)	Activity limits for exempt consignments (Ci)
Only beta- or gamma-emitting radionuclides are known to be present	1×10^{1}	2.7×10^{-10}	1×10^{4}	2.7×10^{-7}
Alpha-emitting nuclides, but no neutron emitters are known to be present	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}
Neutron-emitting nuclides are known to be present or no relevant data are available	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}

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