

1.1 **Department of Health**

1.2 **Proposed Permanent Rules Governing Radiation Safety**

1.3 **4717.7000 VARIANCE REQUEST.**

1.4 Subpart 1. **Request.** A party may ask the commissioner of health to grant a variance
1.5 from the following rules:

1.6 [For text of items A to P, see M.R.]

1.7 Q. ionizing radiation, parts 4732.0100 to 4732.1130, except parts 4732.0200 and
1.8 4732.0210; ~~and~~

1.9 R. lead poisoning prevention, parts 4761.2000 to 4761.2700, except parts
1.10 4761.2000, 4761.2100, 4761.2200, 4761.2220, and 4761.2510; and

1.11 S. radioactive materials, parts 4731.0100 to 4731.8140.

1.12 [For text of subps 2 and 3, see M.R.]

1.13 **4731.0100 DEFINITIONS.**

1.14 [For text of subps 1 to 50, see M.R.]

1.15 Subp. 50a. **Criticality safety index or CSI.** "Criticality safety index" or "CSI" means
1.16 the dimensionless number, rounded up to the next tenth, assigned to and placed on the label
1.17 of a fissile material package, to designate the degree of control of accumulation of packages,
1.18 overpacks, or freight containers containing fissile material during transportation.

1.19 Determination of the criticality safety index is described in parts 4731.0410 and 4731.0411
1.20 and Code of Federal Regulations, title 10, section 71.59. The criticality safety index for an
1.21 overpack, freight container, consignment, or conveyance containing fissile material packages
1.22 is the arithmetic sum of the criticality safety indices of all the fissile material packages
1.23 contained within the overpack, freight container, consignment, or conveyance.

1.24 [For text of subps 51 to 83a, see M.R.]

2.1 Subp. 84. **Fissile material.** "Fissile material" means the radionuclides plutonium-239,
2.2 plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides.
2.3 Fissile material means the fissile nuclides themselves, not material containing fissile nuclides.
2.4 Unirradiated natural uranium and depleted uranium and natural uranium or depleted uranium,
2.5 that has been irradiated in thermal reactors only, are not included in this definition. Certain
2.6 exclusions from fissile material controls are provided in parts 4731.0400 to ~~4731.0455~~
2.7 4731.0424.

2.8 [For text of subps 85 to 100, see M.R.]

2.9 Subp. 100a. **Indian ~~tribe~~ Tribe.** "Indian ~~tribe~~ Tribe" means an Indian or Alaska Native
2.10 ~~tribe~~ Tribe, band, nation, pueblo, village, or community that the Secretary of the Interior
2.11 acknowledges to exist as an Indian ~~tribe~~ Tribe pursuant to the Federally Recognized Indian
2.12 Tribe List Act of 1994, United States Code, title 25, section 479a.

2.13 [For text of subps 101 to 128, see M.R.]

2.14 Subp. 129. **Low specific activity material or LSA.** "Low specific activity material"
2.15 or "LSA" means radioactive material with limited specific activity ~~which~~ that is nonfissile
2.16 or is excepted under part 4731.0403, subpart 3, and that satisfies the descriptions and limits
2.17 in subpart 130, 131, or 132. Shielding materials surrounding the LSA material may not be
2.18 considered in determining the estimated average specific activity of the package contents.
2.19 LSA material must be in group I, group II, or group III.

2.20 Subp. 130. **Low specific activity material group I.** "Low specific activity material
2.21 group I" means:

2.22 A. uranium and thorium ores, concentrates of uranium and thorium ores, and other
2.23 ores containing naturally occurring radioactive radionuclides ~~which~~ that are ~~not~~ intended
2.24 to be processed for the use of these radionuclides;

3.1 B. ~~solid- or liquid-irradiated~~ natural uranium or, depleted uranium or, natural thorium, or
3.2 their ~~solid or liquid~~ compounds or mixtures, provided they are unirradiated and in solid or
3.3 liquid form;

3.4 C. radioactive material other than fissile material, for which the A_2 value is
3.5 unlimited; or

3.6 [For text of item D, see M.R.]

3.7 Subp. 131. **Low specific activity material group II.** "Low specific activity material
3.8 group II" means:

3.9 A. water with tritium concentration up to 20.0 Ci/liter (0.8 TBq/liter); or

3.10 B. other radioactive material in which the activity is distributed throughout and
3.11 the estimated average specific activity does not exceed $10^{-4} A_2/g$ for solids and gases or
3.12 $10^{-5} A_2/g$ for liquids.

3.13 Subp. 132. **Low specific activity material group III.** "Low specific activity material
3.14 group III" means solids, such as consolidated wastes and activated materials, excluding
3.15 powders, that satisfy the requirements in Code of Federal Regulations, title 10, section
3.16 71.77, in which:

3.17 [For text of items A and B, see M.R.]

3.18 C. the estimated average specific activity of the solid, excluding any shielding
3.19 material, does not exceed $2 \times 10^{-3} A_2/g$.

3.20 [For text of subps 133 to 148, see M.R.]

3.21 Subp. 149. **Natural uranium.** "Natural uranium" means uranium, which may be
3.22 chemically separated, with the naturally occurring distribution of uranium isotopes,
3.23 approximately 0.711 weight percent uranium-235, and the remainder by weight essentially
3.24 uranium-238.

4.1 [For text of subps 150 to 223, see M.R.]

4.2 Subp. 224. **Special form radioactive material.** "Special form radioactive material"
4.3 means radioactive material that satisfies the following conditions:

4.4 [For text of items A and B, see M.R.]

4.5 C. it satisfies the requirements of Code of Federal Regulations, title 10, section
4.6 71.75. A special form encapsulation designed according to Code of Federal Regulations,
4.7 title 10, section 71.4, in effect on June 30, 1983, and constructed before July 1, 1985, ~~and~~
4.8 a special form encapsulation designed according to Code of Federal Regulations, title 10,
4.9 section 71.4, in effect on March 31, 1996, and constructed before April 1, 1998, and special
4.10 form material that was successfully tested before September 10, 2015, according to the
4.11 requirements of Code of Federal Regulations, title 10, section 71.75(d), in effect before
4.12 September 10, 2015, may continue to be used. Any other special form encapsulation must
4.13 meet the specifications of this subpart.

4.14 [For text of subps 225 to 247, see M.R.]

4.15 Subp. 247a. **Tribal official.** "Tribal official" means the highest ranking individual
4.16 that represents ~~tribal~~ Tribal leadership, such as the chief, president, or ~~tribal~~ Tribal council
4.17 leadership.

4.18 [For text of subps 248 to 269, see M.R.]

4.19 **4731.0200 GENERAL APPLICATIONS.**

4.20 [For text of subps 1 to 4, see M.R.]

4.21 Subp. 5. **Telephone notifications.** Telephone notifications required by this chapter
4.22 must be made to the Radioactive Materials Unit at 651-201-4400. If an immediate or 24-hour
4.23 notification is required after business hours or if no one can be reached at the contact
4.24 telephone number, notify the Minnesota duty officer at 651-649-5451 or 1-800-422-0798.

5.1 **4731.0355 RECIPROCITY.**5.2 [For text of subps 1 and 2, see M.R.]5.3 Subp. 3. **Notification.**5.4 [For text of item A, see M.R.]

5.5 B. The out-of-state licensee must:

5.6 (1) notify the commissioner of any changes in the work location, schedule,
5.7 radioactive material, or work activities prior to the scheduled work;5.8 [For text of subitems (2) and (3), see M.R.]5.9 [For text of items C and D, see M.R.]5.10 [For text of subp 4, see M.R.]5.11 **4731.0400 SCOPE; ENFORCEMENT NOTICE.**5.12 Subpart 1. **Scope.** Parts 4731.0400 to ~~4731.0455~~ 4731.0424 establish requirements
5.13 for the packaging, preparation for shipment, and transportation of licensed material.5.14 Subp. 2. **Application of other law.** The packaging and transport of licensed material
5.15 are subject to this chapter; ~~Code of Federal Regulations, title 10, parts 21, 70, and 73;~~ and
5.16 the regulations of other agencies, such as the NRC, DOT, and United States Postal Service,
5.17 having jurisdiction over means of transport. The requirements of parts 4731.0400 to
5.18 ~~4731.0455~~ 4731.0424 are in addition to, and not in substitution for, other requirements.5.19 Subp. 3. **Applicability.**5.20 ~~A.~~ Parts 4731.0400 to ~~4731.0455~~ 4731.0424 apply to any licensee authorized by
5.21 a specific or general license issued by the commissioner to receive, possess, use, or transfer
5.22 licensed material, if the licensee delivers that material to a carrier for transport, transports
5.23 the material outside the site of usage as specified in an NRC or agreement state license, or

6.1 transports that material on public highways. Parts 4731.0400 to ~~4731.0455~~ 4731.0424 do
6.2 not authorize possession of licensed material.

6.3 ~~B. Parts 4731.0400 to 4731.0455 apply to any person required to obtain a certificate~~
6.4 ~~of compliance if the person delivers radioactive material to a common or contract carrier~~
6.5 ~~for transport or transports the material outside the confines of the person's plant or other~~
6.6 ~~authorized place of use.~~

6.7 Subp. 4. **Enforcement notice Definitions.** This part is notice to all persons who
6.8 knowingly provide to any licensee; radiographer certificate holder; quality assurance program
6.9 approval holder; applicant for a license, radiographer certificate, or quality assurance program
6.10 approval; or contractor or subcontractor of any of them components, equipment, materials,
6.11 or other goods or services, that relate to a licensee's, certificate holder's, quality assurance
6.12 program approval holder's, or applicant's activities subject to parts 4731.0400 to 4731.0455,
6.13 that they may be individually subject to the commissioner's enforcement action for violation
6.14 of part ~~4731.0280~~. The following definitions apply to parts 4731.0400 to 4731.0424.

6.15 A. Contamination means the presence of a radioactive substance on a surface in
6.16 quantities in excess of 1×10^{-5} $\mu\text{Ci}/\text{cm}^2$ ($0.4 \text{ Bq}/\text{cm}^2$) for beta and gamma emitters and
6.17 low-toxicity alpha emitters, or (1×10^{-6} $\mu\text{Ci}/\text{cm}^2$) $0.04 \text{ Bq}/\text{cm}^2$ for all other alpha emitters.

6.18 B. Fixed contamination means contamination that cannot be removed from a
6.19 surface during normal conditions of transport.

6.20 C. Nonfixed contamination means contamination that can be removed from a
6.21 surface during normal conditions of transport.

6.22 **4731.0401 REQUIREMENT FOR LICENSE.**

6.23 No licensee shall deliver licensed material to a carrier for transport or transport licensed
6.24 material, except as authorized in a general license or a specific license issued by the
6.25 commissioner or as exempted under parts 4731.0400 to ~~4731.0455~~ 4731.0424.

7.1 **4731.0403 SPECIFIC EXEMPTIONS.**7.2 [For text of subp 1, see M.R.]

7.3 Subp. 1a. **Grounds.** On application of any interested person or on the commissioner's
7.4 own initiative, the commissioner may grant any exemption from parts 4731.0400 to
7.5 ~~4731.0455~~ 4731.0424 that the commissioner determines is authorized by law and will not
7.6 endanger life or property nor the common defense and security.

7.7 Subp. 2. **Low-level materials.** A licensee is exempt from the requirements of parts
7.8 4731.0400 to ~~4731.0455~~ 4731.0424 with respect to shipment or carriage of a package of
7.9 the following low-level material:

7.10 A. natural material and ores containing naturally occurring radionuclides that are
7.11 either in their natural state, or have only been processed for purposes other than for the
7.12 extraction of the radionuclides, and that are not intended to be processed for use of these
7.13 radionuclides, provided the activity concentration of the material does not exceed ten times
7.14 the applicable radionuclide activity concentration values specified in part 4731.0422, subpart
7.15 3; ~~and~~

7.16 B. materials for which the activity concentration is not greater than the activity
7.17 concentration values specified in part 4731.0422, subpart 3, or for which the consignment
7.18 activity is not greater than the limit for an exempt consignment under part 4731.0422, subpart
7.19 3; and

7.20 C. Nonradioactive solid objects with radioactive substances present on any surfaces
7.21 in quantities that do not exceed of the levels cited in the definition of contamination in part
7.22 4731.0400, subpart 4, item A.

7.23 Subp. 3. **Exemption from classification as fissile material.** Fissile material meeting
7.24 at least one of the requirements in items A to F is exempt from classification as fissile
7.25 material and from the fissile material package standards of Code of Federal Regulations,

8.1 title 10, sections 71.55 and 71.59, but is subject to all other requirements of this chapter,
8.2 except as noted:

8.3 [For text of items A to C, see M.R.]

8.4 D. uranium enriched in uranium-235 to a maximum of one percent by weight,
8.5 and with total plutonium and uranium-233 content of up to one percent of the mass of
8.6 uranium-235, provided that the mass of any beryllium, graphite, and hydrogenous material
8.7 enriched in deuterium constitutes less than five percent of the uranium mass, and that the
8.8 fissile material is distributed homogenously and does not form a lattice arrangement within
8.9 the package;

8.10 [For text of items E and F, see M.R.]

8.11 **4731.0406 GENERAL LICENSE; NRC-APPROVED PACKAGE.**

8.12 [For text of subps 1 and 2, see M.R.]

8.13 Subp. 3. **Compliance with conditions.**

8.14 A. ~~The~~ Each licensee issued a general license issued under subpart 1 ~~applies only~~
8.15 ~~to a licensee who~~ must:

8.16 A. (1) has maintain a copy of the certificate of compliance or other approval of
8.17 the package and has the drawings and other documents referenced in the approval relating
8.18 to the use and maintenance of the packaging and to the actions to be taken before shipment;

8.19 B. (2) complies comply with the terms and conditions of the license, certificate,
8.20 or other approval, as applicable, and the applicable requirements of this chapter and Code
8.21 of Federal Regulations, title 10, part 71, subpart H; and

8.22 C. (3) submits submit in writing to the NRC, before the licensee's first use of the
8.23 package, the licensee's name and license number and the package identification number
8.24 specified in the package approval. For the submittal to the NRC, the licensee must use an

9.1 approved method listed in the Code of Federal Regulations, title 10, section 71.1(a), addressed
9.2 to: ATTN: Document Control Desk, Director, Division of Spent Fuel Storage and
9.3 Transportation, Office of Nuclear Material Safety and Safeguards.

9.4 Subp. 4. **Package approval.** ~~B.~~ The general license issued under subpart 1 applies
9.5 only when the package approval authorizes use of the package under the general license
9.6 under subpart 1.

9.7 Subp. 5. **Type B or fissile material package.** ~~C.~~ For a Type B or fissile material
9.8 package, the design of which was approved by the NRC before April 1, 1996, the general
9.9 license under subpart 1 is subject to the additional restrictions of Code of Federal Regulations,
9.10 title 10, section 71.19.

9.11 **4731.0409 GENERAL LICENSE; FOREIGN-APPROVED PACKAGE.**

9.12 Subpart 1. **License for foreign-approved package.** A general license is issued to any
9.13 licensee of the commissioner to transport, or to deliver to a carrier for transport, licensed
9.14 material in a package the design of which has been approved in a foreign national competent
9.15 authority certificate that has been revalidated by the DOT as meeting the applicable
9.16 requirements of Code of Federal Regulations, title 49, section ~~471.12~~ 171.23.

9.17 Subp. 2. **Approved quality assurance program.** Except as otherwise provided in
9.18 parts 4731.0400 to ~~4731.0455~~ 4731.0424, the general license issued under subpart 1 applies
9.19 only to a licensee who has a quality assurance program approved by the NRC as complying
9.20 with Code of Federal Regulations, title 10, part 71, subpart H.

9.21 Subp. 3. **Use outside United States.** The general license issued under subpart 1 applies
9.22 only to shipments made to or from locations outside the United States.

9.23 Subp. 4. **Certificate conditions.** ~~The general license~~ Each licensee issued a general
9.24 license under subpart 1 applies only to a licensee who must:

10.1 A. ~~has~~ maintain a copy of the applicable certificate, the revalidation, and the
10.2 drawings and other documents referenced in the certificate, relating to the use and
10.3 maintenance of the packaging and to the actions to be taken before shipment; and

10.4 B. ~~complies~~ comply with the terms and conditions of the certificate and revalidation
10.5 and with the applicable requirements of this chapter and Code of Federal Regulations, title
10.6 10, part 71, subpart H. ~~With respect to the quality assurance provisions of Code of Federal~~
10.7 ~~Regulations, title 10, part 71, subpart H, the licensee is exempt from design, construction,~~
10.8 ~~and fabrication considerations.~~

10.9 **4731.0414 PRELIMINARY DETERMINATIONS.**

10.10 Before the first use of any packaging for the shipment of licensed material: the licensee
10.11 must ascertain that the determinations in Code of Federal Regulations, title 10, part 71.85,
10.12 have been made.

10.13 A. ~~a licensee must ascertain that there are no cracks, pinholes, uncontrolled voids,~~
10.14 ~~or other defects that could significantly reduce the effectiveness of the packaging;~~

10.15 B. ~~where the maximum normal operating pressure will exceed five pounds per~~
10.16 ~~square inch (35 kilopascal) gauge, a licensee must test the containment system at an internal~~
10.17 ~~pressure of at least 50 percent higher than the maximum normal operating pressure, to verify~~
10.18 ~~the capability of that system to maintain its structural integrity at that pressure; and~~

10.19 C. ~~a licensee must conspicuously and durably mark the packaging with its model~~
10.20 ~~number, serial number, gross weight, and a package identification number assigned by the~~
10.21 ~~NRC. Before applying the model number, a licensee must determine that the packaging has~~
10.22 ~~been fabricated according to a design approved by the NRC.~~

11.1 **4731.0415 ROUTINE DETERMINATIONS.**

11.2 Before each shipment of licensed material, a licensee must ensure that the package
11.3 with its contents satisfies the applicable requirements of the license and parts 4731.0400 to
11.4 ~~4731.0455~~ 4731.0424. The licensee must determine that:

11.5 [For text of items A to K, see M.R.]

11.6 **4731.0416 AIR TRANSPORT OF PLUTONIUM.**

11.7 Subpart 1. **Limitations for plutonium transport.** Notwithstanding the provisions of
11.8 any general license and notwithstanding any exemptions stated directly in parts 4731.0400
11.9 to ~~4731.0455~~ 4731.0424 or included indirectly by citation to Code of Federal Regulations,
11.10 title 49, chapter I, as may be applicable, a licensee must ensure that plutonium in any form,
11.11 whether for import, export, or domestic shipment, is not transported by air, or delivered to
11.12 a carrier for air transport, unless:

11.13 [For text of items A to D, see M.R.]

11.14 [For text of subp 2, see M.R.]

11.15 **4731.0418 RECORDS AND REPORTS.**

11.16 Subpart 1. **Record of shipment.** Each licensee must maintain, for a period of three
11.17 years after shipment, a record of each shipment of licensed material that is not exempt under
11.18 part 4731.0403, subpart 2, showing where applicable:

11.19 A. identification of the packaging by model number and serial number;

11.20 B. verification that there are no significant defects in the packaging, as shipped;

11.21 C. volume and identification of coolant;

11.22 D. type and quantity of licensed material in each package, and the total quantity
11.23 of each shipment;

- 12.1 E. for each item of irradiated fissile material:
- 12.2 (1) identification by model number and serial number;
- 12.3 (2) irradiation and decay history to the extent appropriate to demonstrate that
- 12.4 its nuclear and thermal characteristics comply with license conditions; and
- 12.5 (3) any abnormal or unusual condition relevant to radiation safety;
- 12.6 F. date of the shipment;
- 12.7 G. for fissile packages and for Type B packages, any special controls exercised;
- 12.8 H. name and address of the transferee;
- 12.9 I. address to which the shipment was made; and
- 12.10 J. results of the determinations required by part 4731.0415 and by the conditions
- 12.11 of the package approval.
- 12.12 Subp. 2. **Record availability.** The licensee must make available to the commissioner
- 12.13 for inspection, upon reasonable notice, all records required by parts 4731.0400 to 4731.0424.
- 12.14 Records are only valid if stamped, initialed, or signed and dated by authorized personnel,
- 12.15 or otherwise authenticated.
- 12.16 Subp. 3. **Record of package quality.** The licensee must maintain sufficient written
- 12.17 records to furnish evidence of the quality of packaging. The records to be maintained include
- 12.18 results of the determinations required by Code of Federal Regulations, title 10, part 71.85;
- 12.19 design, fabrication, and assembly records; results of reviews, inspections, tests, and audits;
- 12.20 results of monitoring work performance and materials analyses; and results of maintenance,
- 12.21 modification, and repair activities. Inspection, test, and audit records must identify the
- 12.22 inspector or data recorder, the type of observation, the results, the acceptability, and the
- 12.23 action taken in connection with any deficiencies noted. These records must be retained for
- 12.24 three years after the life of the packaging to which they apply.

13.1 Subp. 4. Reports. A licensee must report to the commissioner within 30 days:

13.2 A. any instance in which there is significant reduction in the effectiveness of any
13.3 approved Type B or fissile packaging during use;

13.4 B. details of any defects with safety significance in Type B or fissile packaging
13.5 after first use, with the means employed to repair the defects and prevent their recurrence;
13.6 and

13.7 C. instances in which the conditions of approval in the certificate of compliance
13.8 were not observed in making a shipment.

13.9 **4731.0419 ADVANCE NOTIFICATION OF SHIPMENT OF IRRADIATED**
13.10 **REACTOR FUEL AND NUCLEAR WASTE.**

13.11 Subpart 1. **Notice required.** As specified in subparts 2 to 4, a licensee must provide
13.12 advance notification to:

13.13 A. the commissioner; and the governor of the state or the governor's designee;
13.14 ~~and the NRC~~ of a shipment of licensed material through or across the boundary of the state
13.15 before the transport, or delivery to a carrier for transport, of licensed material outside the
13.16 confines of the licensee's plant or other place of use or storage; and

13.17 B. the ~~tribal~~ Tribal official of participating ~~tribes~~ Tribes referenced in subpart 3,
13.18 item B, or the official's designee, of the shipment of licensed material, within or across the
13.19 boundary of the ~~tribe's~~ Tribe's reservation, before the transport, or delivery to a carrier, for
13.20 transport, of licensed material outside the confines of the licensee's plant or other place of
13.21 use or storage.

13.22 Subp. 2. **Shipments requiring notice.** Advance notification is required under this
13.23 part for shipments of licensed material, other than irradiated fuel, meeting the following
13.24 three conditions:

14.1 A. the licensed material is required by parts 4731.0400 to ~~4731.0455~~ 4731.0424
14.2 to be in Type B packaging for transportation;

14.3 [For text of items B and C, see M.R.]

14.4 Subp. 3. **Procedures for submitting notification.**

14.5 A. The notification required under this part must:

14.6 (1) be made in writing to the commissioner, the office of each appropriate
14.7 state governor or governor's designee, and the office of each appropriate ~~tribal~~ Tribal official
14.8 or ~~tribal~~ Tribal official's designee, ~~and to the director of the Division of Security Policy,~~
14.9 ~~Office of Nuclear Security and Incident Response, NRC;~~

14.10 [For text of subitem (2), see M.R.]

14.11 (3) if delivered by any other means than mail, reach the office of the
14.12 commissioner and the governor or governor's designee or the ~~tribal~~ Tribal official or ~~tribal~~
14.13 Tribal official's designee at least four days before the beginning of the seven-day period
14.14 during which departure of the shipment is estimated to occur.

14.15 B. ~~A list of the names~~ Contact information, including telephone and mailing
14.16 addresses of the governors' designees and ~~tribal~~ Tribal officials' designees of participating
14.17 ~~tribes receiving advance notification of transportation of nuclear waste~~ Tribes ~~is published~~
14.18 ~~annually in the Federal Register on or about June 30 to reflect changes in information~~
14.19 ~~available on the NRC Web site at: <https://scp.nrc.gov/special/designee.pdf>.~~ The list
14.20 information is also available on request from the Director, ~~Office of Federal and State~~
14.21 ~~Materials and Environmental Programs~~ Division of Material Safety, State, Tribal, and
14.22 Rulemaking Programs, Office of Nuclear Material Safety and Safeguards, United States
14.23 Nuclear Regulatory Commission, Washington, DC 20555-0001.

14.24 [For text of item C, see M.R.]

15.1 Subp. 4. **Information to be furnished in advance notification of shipment.** An
15.2 advance notification of shipment of irradiated reactor fuel or nuclear waste must contain
15.3 the following information:

15.4 [For text of items A to C, see M.R.]

15.5 D. the seven-day period during which arrival of the shipment at state boundaries
15.6 or ~~tribal~~ Tribal reservation boundaries is estimated to occur;

15.7 [For text of items E and F, see M.R.]

15.8 Subp. 5. **Revision notice.** A licensee who finds that schedule information, previously
15.9 furnished under this part to the commissioner and a governor or governor's designee or a
15.10 ~~tribal~~ Tribal official or ~~tribal~~ Tribal official's designee, will not be met must telephone a
15.11 responsible individual in the commissioner's office and the governor or governor's designee
15.12 or the ~~tribal~~ Tribal official or the ~~tribal~~ Tribal official's designee and inform the individual
15.13 of the extent of the delay beyond the schedule originally reported.

15.14 [For text of subp 5a, see M.R.]

15.15 Subp. 6. **Cancellation notice.**

15.16 A. A licensee who cancels an irradiated reactor fuel or nuclear waste shipment
15.17 for which advance notification has been sent must send a cancellation notice to the
15.18 commissioner, the governor of each state or the governor's designee previously notified,
15.19 and each ~~tribal~~ Tribal official or the ~~tribal~~ Tribal official's designee previously notified, ~~and~~
15.20 ~~the director of the Division of Security Policy, Office of Nuclear Security and Incident~~
15.21 ~~Response, NRC.~~

15.22 [For text of items B and C, see M.R.]

16.1 **4731.0420 QUALITY ASSURANCE REQUIREMENTS.**

16.2 Subpart 1. **Program requirement.**

16.3 A. A licensee who uses a general license under part 4731.0406, 4731.0409,
16.4 4731.0410, or 4731.0411, must establish, maintain, and execute a quality assurance program
16.5 satisfying each of the applicable criteria of this part ~~and part 4731.0421 and Code of Federal~~
16.6 ~~Regulations, title 10, part 71, subpart H, and satisfying any specific provisions that are~~
16.7 ~~applicable to the licensee's activities, including procurement of packaging. A licensee must~~
16.8 ~~apply each of the applicable criteria in a graded approach, to an extent that is consistent~~
16.9 ~~with the criteria's importance to safety.~~

16.10 [For text of item B, see M.R.]

16.11 C. Before the use of any package for the shipment of licensed material subject to
16.12 this part, a licensee must obtain the commissioner's approval of its quality assurance program.
16.13 The licensee must file a description of its quality assurance program, including a discussion
16.14 of which requirements of this part are applicable and how they will be satisfied.

16.15 D. A program for transport container inspection and maintenance limited to
16.16 radiographic exposure devices, source changers, or packages transporting these devices and
16.17 meeting the requirements of part 4731.4090, subpart 2, item A, or an equivalent requirement
16.18 of the NRC or an agreement state, is deemed to satisfy the requirements of subpart 1 and
16.19 part 4731.0406, subpart 2.

16.20 Subp. 2. **Radiography containers** Quality assurance organization. ~~A program for~~
16.21 ~~transport container inspection and maintenance limited to radiographic exposure devices,~~
16.22 ~~source changers, or packages transporting these devices and meeting the requirements of~~
16.23 ~~part 4731.4090, subpart 2, item A, or an equivalent requirement of the NRC or an agreement~~
16.24 ~~state, is deemed to satisfy the requirements of subpart 1 and part 4731.0406, subpart 2.~~

17.1 A. A licensee is responsible for the establishment and execution of the quality
17.2 assurance program. The licensee may delegate to others, such as contractors, agents, or
17.3 consultants, the work of establishing and executing the quality assurance program, or any
17.4 part of the quality assurance program, but must retain responsibility for the program. These
17.5 activities include performing the functions associated with attaining quality objectives and
17.6 the quality assurance functions.

17.7 B. The quality assurance functions are:

17.8 (1) assuring that an appropriate quality assurance program is established and
17.9 effectively executed; and

17.10 (2) verifying, by procedures such as checking, auditing, and inspection, that
17.11 activities affecting the functions important to safety have been correctly performed.

17.12 Subp. 3. **Quality assurance program.**

17.13 A. The licensee must document the quality assurance program by written
17.14 procedures or instructions and carry out the program according to those procedures
17.15 throughout the period during which the packaging is used. The licensee must identify the
17.16 material and components to be covered by the quality assurance program, the major
17.17 organizations participating in the program, and the designated functions of these
17.18 organizations.

17.19 B. The licensee, through its quality assurance program, must provide control over
17.20 activities affecting the quality of the identified materials and components to an extent
17.21 consistent with their importance to safety, and as necessary to ensure conformance to the
17.22 approved design of each individual package used for the shipment of radioactive material.
17.23 The licensee must ensure that activities affecting quality are accomplished under suitably
17.24 controlled conditions. Controlled conditions include the use of appropriate equipment;
17.25 suitable environmental conditions for accomplishing the activity, such as adequate

18.1 cleanliness; and assurance that all prerequisites for the given activity have been satisfied.

18.2 The licensee must take into account the need for special controls, processes, test equipment,

18.3 tools, and skills to attain the required quality and the need for verification of quality by

18.4 inspection and test.

18.5 C. The licensee must base the requirements and procedures of its quality assurance

18.6 program on the following considerations concerning the complexity and proposed use of

18.7 the package and its components:

18.8 (1) the impact of malfunction or failure of the item to safety;

18.9 (2) the design and fabrication complexity or uniqueness of the item;

18.10 (3) the need for special controls and surveillance over processes and

18.11 equipment;

18.12 (4) the degree to which functional compliance can be demonstrated by

18.13 inspection or test; and

18.14 (5) the quality history and degree of standardization of the item.

18.15 D. The licensee must provide for the indoctrination and training of personnel who

18.16 perform activities that affect quality, as necessary to ensure that suitable proficiency is

18.17 achieved and maintained. The licensee must review the status and adequacy of the quality

18.18 assurance program at established intervals. Management of other organizations participating

18.19 in the quality assurance program shall review regularly the status and adequacy of that part

18.20 of the quality assurance program that a participating organization is executing.

18.21 Subp. 4. **Changes to quality assurance program.**

18.22 A. A quality assurance program approval holder must submit a description of a

18.23 proposed change to its commissioner-approved quality assurance program that will reduce

18.24 commitments in the program description as approved by the commissioner. The quality

19.1 assurance program approval holder shall not implement the change before receiving
19.2 commissioner approval. The description of a proposed change to the commissioner approved
19.3 quality assurance program must identify the change, the reason for the change, and the basis
19.4 for concluding that the revised program incorporating the change continues to satisfy the
19.5 applicable requirements of this part.

19.6 B. Each quality assurance program approval holder may change a previously
19.7 approved quality assurance program without prior approval from the commissioner, if the
19.8 change does not reduce the commitments in the quality assurance program previously
19.9 approved by the commissioner. Changes to the quality assurance program that do not reduce
19.10 the commitments must be submitted to the commissioner every 24 months. In addition to
19.11 quality assurance program changes involving administrative improvements and clarifications,
19.12 spelling corrections, and nonsubstantive changes to punctuation or editorial items, the
19.13 following changes are not considered reductions in commitment:

19.14 (1) the use of a quality assurance standard approved by the commissioner
19.15 that is more recent than the quality assurance standard in the certificate holder's or applicant's
19.16 current quality assurance program at the time of the change;

19.17 (2) the use of generic organizational position titles that clearly denote the
19.18 position function, supplemented as necessary by descriptive text rather than specific titles,
19.19 provided that there is no substantive change to either the functions of the position or reporting
19.20 responsibilities;

19.21 (3) the use of generic organizational charts to indicate functional relationships,
19.22 authorities, and responsibilities, or alternatively, the use of descriptive text, provided that
19.23 there is no substantive change to the functional relationships, authorities, or responsibilities;

19.24 (4) the elimination of quality assurance program information that duplicates
19.25 language in quality assurance regulatory guides and quality assurance standards which the
19.26 quality assurance program approval holder has committed to on record; and

20.1 (5) organizational revisions that ensure persons and organizations performing
20.2 quality assurance functions continue to have the requisite authority and organizational
20.3 freedom, including sufficient independence from cost and schedule when opposed to safety
20.4 considerations.

20.5 C. Each quality assurance program approval holder must maintain records of
20.6 quality assurance program changes.

20.7 Subp. 5. **Handling, storage, and shipping control.** The licensee must establish
20.8 measures to control, according to instructions, the handling, storage, shipping, cleaning,
20.9 and preservation of materials and equipment to be used in packaging to prevent damage or
20.10 deterioration. When necessary for particular products, special protective environments, such
20.11 as inert gas atmosphere, and specific moisture content and temperature levels must be
20.12 specified and provided.

20.13 Subp. 6. **Inspection, test, and operating status.**

20.14 A. The licensee must establish measures to indicate, by the use of markings such
20.15 as stamps, tags, labels, routing cards, or other suitable means, the status of inspections and
20.16 tests performed upon individual items of the packaging. These measures must provide for
20.17 the identification of items that have satisfactorily passed required inspections and tests,
20.18 where necessary, to preclude inadvertent bypassing of the inspections and tests.

20.19 B. The licensee must establish measures to identify the operating status of
20.20 components of the packaging, such as tagging valves and switches, to prevent inadvertent
20.21 operation.

20.22 Subp. 7. **Nonconforming materials, parts, or components.** The licensee must
20.23 establish measures to control materials, parts, or components that do not conform to the
20.24 licensee's requirements to prevent inadvertent use or installation. These measures must
20.25 include, as appropriate, procedures for identification, documentation, segregation, disposition,

21.1 and notification to affected organizations. Nonconforming items must be reviewed and
21.2 accepted, rejected, repaired, or reworked according to documented procedures.

21.3 Subp. 8. **Corrective action.** The licensee must establish measures to ensure that
21.4 conditions adverse to quality, such as deficiencies, deviations, defective material and
21.5 equipment, and nonconformances, are promptly identified and corrected. In the case of a
21.6 significant condition that is adverse to quality, the measures must ensure that the cause of
21.7 the condition is determined and corrective action is taken to preclude repetition. The
21.8 identification of the significant condition that is adverse to quality, the cause of the condition,
21.9 and the corrective action taken must be documented and reported to appropriate levels of
21.10 management.

21.11 Subp. 9. **Quality assurance records.** The licensee must maintain sufficient written
21.12 records to describe the activities affecting quality. These records must include changes to
21.13 the quality assurance program as required by subpart 4, and closely related specifications,
21.14 such as required qualifications of personnel, procedures, and equipment. The records must
21.15 include the instructions or procedures that establish a records retention program that is
21.16 consistent with applicable regulations and that designates factors such as duration, location,
21.17 and assigned responsibility for the records. The licensee must retain these records for three
21.18 years beyond the date when the licensee last engages in the activity for which the quality
21.19 assurance program was developed. If any portion of the quality assurance program, written
21.20 procedures, or instructions is superseded, the licensee must retain the superseded material
21.21 for three years.

21.22 Subp. 10. **Audits.** The licensee must carry out a comprehensive system of planned
21.23 and periodic audits to verify compliance with all aspects of the quality assurance program
21.24 and determine the effectiveness of the program. The audits must be performed according
21.25 to written procedures or checklists by appropriately trained personnel who do not have
21.26 direct responsibilities in the areas being audited. Audited results must be documented and

22.1 reviewed by management having responsibility in the area audited. Follow-up action,
 22.2 including reaudit of deficient areas, must be taken where indicated.

22.3 **4731.0422 A₁ AND A₂ VALUES FOR RADIONUCLIDES.**

22.4 Subpart 1. [Repealed, 32 SR 831]

22.5 Subp. 1a. **A₁ and A₂ values.**

22.6 Element and atomic
 22.7 number and symbol
 22.8 of radionuclide

22.9		A ₁ (TBq)	A ₁ (Ci) ^b	A ₂ (TBq)	A ₂ (Ci) ^b
22.10	Actinium (89)				
22.11	Ac-225 ^a	8.0 x 10 ⁻¹	2.2 x 10 ¹	6.0 x 10 ⁻³	1.6 x 10 ⁻¹
22.12	Ac-227 ^a	9.0 x 10 ⁻¹	2.4 x 10 ¹	9.0 x 10 ⁻⁵	2.4 x 10 ⁻³
22.13	Ac-228	6.0 x 10 ⁻¹	1.6 x 10 ¹	5.0 x 10 ⁻¹	1.4 x 10 ¹
22.14	Silver (47)				
22.15	Ag-105	2.0	5.4 x 10 ¹	2.0	5.4 x 10 ¹
22.16	Ag-108m ^a	7.0 x 10 ⁻¹	1.9 x 10 ¹	7.0 x 10 ⁻¹	1.9 x 10 ¹
22.17	Ag-110m ^a	4.0 x 10 ⁻¹	1.1 x 10 ¹	4.0 x 10 ⁻¹	1.1 x 10 ¹
22.18	Ag-111	2.0	5.4 x 10 ¹	6.0 x 10 ⁻¹	1.6 x 10 ¹
22.19	Aluminum (13)				
22.20	Al-26	1.0 x 10 ⁻¹	2.7	1.0 x 10 ⁻¹	2.7
22.21	Americium (95)				
22.22	Am-241	1.0 x 10 ¹	2.7 x 10 ²	1.0 x 10 ⁻³	2.7 x 10 ⁻²
22.23	Am-242m ^a	1.0x 10 ¹	2.7 x 10 ²	1.0 x 10 ⁻³	2.7 x 10 ⁻²
22.24	Am-243 ^a	5.0	1.4 x 10 ²	1.0 x 10 ⁻³	2.7 x 10 ⁻²
22.25	Argon (18)				

23.1	Ar-37	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
23.2	Ar-39	4.0×10^1	1.1×10^3	2.0×10^1	5.4×10^2
23.3	Ar-41	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
23.4	Arsenic (33)				
23.5	As-72	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
23.6	As-73	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
23.7	As-74	1.0	2.7×10^1	9.0×10^{-1}	2.4×10^1
23.8	As-76	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
23.9	As-77	2.0×10^1	5.4×10^2	7.0×10^{-1}	1.9×10^1
23.10	Astatine (85)				
23.11	At-211 ^a	2.0×10^1	5.4×10^2	5.0×10^{-1}	1.4×10^1
23.12	Gold (79)				
23.13	Au-193	7.0	1.9×10^2	2.0	5.4×10^1
23.14	Au-194	1.0	2.7×10^1	1.0	2.7×10^1
23.15	Au-195	1.0×10^1	2.7×10^2	6.0	1.6×10^2
23.16	Au-198	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
23.17	Au-199	1.0×10^1	2.7×10^2	6.0×10^{-1}	1.6×10^1
23.18	Barium (56)				
23.19	Ba-131 ^a	2.0	5.4×10^1	2.0	5.4×10^1
23.20	Ba-133	3.0	8.1×10^1	3.0	8.1×10^1
23.21	Ba-133m	2.0×10^1	5.4×10^2	6.0×10^{-1}	1.6×10^1
23.22	Ba-140 ^a	5.0×10^{-1}	1.4×10^1	3.0×10^{-1}	8.1
23.23	Beryllium (4)				
23.24	Be-7	2.0×10^1	5.4×10^2	2.0×10^1	5.4×10^2
23.25	Be-10	4.0×10^1	1.1×10^3	6.0×10^{-1}	1.6×10^1

24.1	Bismuth (83)				
24.2	Bi-205	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
24.3	Bi-206	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
24.4	Bi-207	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
24.5	Bi-210	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
24.6	Bi-210m ^a	6.0×10^{-1}	1.6×10^1	2.0×10^{-2}	5.4×10^{-1}
24.7	Bi-212 ^a	7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1
24.8	Berkelium (97)				
24.9	Bk-247	8.0	2.2×10^2	8.0×10^{-4}	2.2×10^{-2}
24.10	Bk-249 ^a	4.0×10^1	1.1×10^3	3.0×10^{-1}	8.1
24.11	Bromine (35)				
24.12	Br-76	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
24.13	Br-77	3.0	8.1×10^1	3.0	8.1×10^1
24.14	Br-82	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
24.15	Carbon (6)				
24.16	C-11	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
24.17	C-14	4.0×10^1	1.1×10^3	3.0	8.1×10^1
24.18	Calcium (20)				
24.19	Ca-41	Unlimited	Unlimited	Unlimited	Unlimited
24.20	Ca-45	4.0×10^1	1.1×10^3	1.0	2.7×10^1
24.21	Ca-47 ^a	3.0	8.1×10^1	3.0×10^{-1}	8.1
24.22	Cadmium (48)				
24.23	Cd-109	3.0×10^1	8.1×10^2	2.0	5.4×10^1
24.24	Cd-113m	4.0×10^1	1.1×10^3	5.0×10^{-1}	1.4×10^1
24.25	Cd-115 ^a	3.0	8.1×10^1	4.0×10^{-1}	1.1×10^1

25.1	Cd-115m	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
25.2	Cerium (58)				
25.3	Ce-139	7.0	1.9×10^2	2.0	5.4×10^1
25.4	Ce-141	2.0×10^1	5.4×10^2	6.0×10^{-1}	1.6×10^1
25.5	Ce-143	9.0×10^{-1}	2.4×10^1	6.0×10^{-1}	1.6×10^1
25.6	Ce-144 ^a	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
25.7	Californium (98)				
25.8	Cf-248	4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}
25.9	Cf-249	3.0	8.1×10^1	8.0×10^{-4}	2.2×10^{-2}
25.10	Cf-250	2.0×10^1	5.4×10^2	2.0×10^{-3}	5.4×10^{-2}
25.11	Cf-251	7.0	1.9×10^2	7.0×10^{-4}	1.9×10^{-2}
25.12	Cf-252 ^b	5.0 $1.0 \times 10^{-2-1}$	1.4 2.7	3.0×10^{-3}	8.1×10^{-2}
25.13	Cf-253 ^a	4.0×10^1	1.1×10^3	4.0×10^{-2}	1.1
25.14	Cf-254	1.0×10^{-3}	2.7×10^{-2}	1.0×10^{-3}	2.7×10^{-2}
25.15	Chlorine (17)				
25.16	Cl-36	1.0×10^1	2.7×10^2	6.0×10^{-1}	1.6×10^1
25.17	Cl-38	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
25.18	Curium (96)				
25.19	Cm-240	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}
25.20	Cm-241	2.0	5.4×10^1	1.0	2.7×10^1
25.21	Cm-242	4.0×10^1	1.1×10^3	1.0×10^{-2}	2.7×10^{-1}
25.22	Cm-243	9.0	2.4×10^2	1.0×10^{-3}	2.7×10^{-2}
25.23	Cm-244	2.0×10^1	5.4×10^2	2.0×10^{-3}	5.4×10^{-2}
25.24	Cm-245	9.0	2.4×10^2	9.0×10^{-4}	2.4×10^{-2}
25.25	Cm-246	9.0	2.4×10^2	9.0×10^{-4}	2.4×10^{-2}
25.26	Cm-247 ^a	3.0	8.1×10^1	1.0×10^{-3}	2.7×10^{-2}

26.1	Cm-248	2.0×10^{-2}	5.4×10^{-1}	3.0×10^{-4}	8.1×10^{-3}
26.2	Cobalt (27)				
26.3	Co-55	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
26.4	Co-56	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
26.5	Co-57	1.0×10^1	2.7×10^2	1.0×10^1	2.7×10^2
26.6	Co-58	1.0	2.7×10^1	1.0	2.7×10^1
26.7	Co-58m	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
26.8	Co-60	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
26.9	Chromium (24)				
26.10	Cr-51	3.0×10^1	8.1×10^2	3.0×10^1	8.1×10^2
26.11	Cesium (55)				
26.12	Cs-129	4.0	1.1×10^2	4.0	1.1×10^2
26.13	Cs-131	3.0×10^1	8.1×10^2	3.0×10^1	8.1×10^2
26.14	Cs-132	1.0	2.7×10^1	1.0	2.7×10^1
26.15	Cs-134	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
26.16	Cs-134m	4.0×10^1	1.1×10^3	6.0×10^{-1}	1.6×10^1
26.17	Cs-135	4.0×10^1	1.1×10^3	1.0	2.7×10^1
26.18	Cs-136	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
26.19	Cs-137 ^a	2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1
26.20	Copper (29)				
26.21	Cu-64	6.0	1.6×10^2	1.0	2.7×10^1
26.22	Cu-67	1.0×10^1	2.7×10^2	7.0×10^{-1}	1.9×10^1
26.23	Dysprosium (66)				
26.24	Dy-159	2.0×10^1	5.4×10^2	2.0×10^1	5.4×10^2
26.25	Dy-165	9.0×10^{-1}	2.4×10^1	6.0×10^{-1}	1.6×10^1

27.1	Dy-166 ^a	9.0×10^{-1}	2.4×10^1	3.0×10^{-1}	8.1
27.2	Erbium (68)				
27.3	Er-169	4.0×10^1	1.1×10^3	1.0	2.7×10^1
27.4	Er-171	8.0×10^{-1}	2.2×10^1	5.0×10^{-1}	1.4×10^1
27.5	Europium (63)				
27.6	Eu-147	2.0	5.4×10^1	2.0	5.4×10^1
27.7	Eu-148	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
27.8	Eu-149	2.0×10^1	5.4×10^2	2.0×10^1	5.4×10^2
27.9	Eu-150 (short-lived)	2.0	5.4×10^1	7.0×10^{-1}	1.9×10^1
27.10	Eu-150 (long-lived)	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
27.11	Eu-152	1.0	2.7×10^1	1.0	2.7×10^1
27.12	Eu-152m	8.0×10^{-1}	2.2×10^1	8.0×10^{-1}	2.2×10^1
27.13	Eu-154	9.0×10^{-1}	2.4×10^1	6.0×10^{-1}	1.6×10^1
27.14	Eu-155	2.0×10^1	5.4×10^2	3.0	8.1×10^1
27.15	Eu-156	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
27.16	Fluorine (9)				
27.17	F-18	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
27.18	Iron (26)				
27.19	Fe-52 ^a	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
27.20	Fe-55	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
27.21	Fe-59	9.0×10^{-1}	2.4×10^1	9.0×10^{-1}	2.4×10^1
27.22	Fe-60 ^a	4.0×10^1	1.1×10^3	2.0×10^{-1}	5.4
27.23	Gallium (31)				
27.24	Ga-67	7.0	1.9×10^2	3.0	8.1×10^1
27.25	Ga-68	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1

28.1	Ga-72	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
28.2	Gadolinium (64)				
28.3	Gd-146 ^a	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
28.4	Gd-148	2.0×10^1	5.4×10^2	2.0×10^{-3}	5.4×10^{-2}
28.5	Gd-153	1.0×10^1	2.7×10^2	9.0	2.4×10^2
28.6	Gd-159	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
28.7	Germanium (32)				
28.8	Ge-68 ^a	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
28.9	Ge-71	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
28.10	Ge-77	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
28.11	Hafnium (72)				
28.12	Hf-172 ^a	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
28.13	Hf-175	3.0	8.1×10^1	3.0	8.1×10^1
28.14	Hf-181	2.0	5.4×10^1	5.0×10^{-1}	1.4×10^1
28.15	Hf-182	Unlimited	Unlimited	Unlimited	Unlimited
28.16	Mercury (80)				
28.17	Hg-194 ^a	1.0	2.7×10^1	1.0	2.7×10^1
28.18	Hg-195m ^a	3.0	8.1×10^1	7.0×10^{-1}	1.9×10^1
28.19	Hg-197	2.0×10^1	5.4×10^2	1.0×10^1	2.7×10^2
28.20	Hg-197m	1.0×10^1	2.7×10^2	4.0×10^{-1}	1.1×10^1
28.21	Hg-203	5.0	1.4×10^2	1.0	2.7×10^1
28.22	Holmium (67)				
28.23	Ho-166	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
28.24	Ho-166m	6.0×10^{-1}	1.6×10^1	5.0×10^{-1}	1.4×10^1

29.1	Iodine (53)				
29.2	I-123	6.0	1.6×10^2	3.0	8.1×10^1
29.3	I-124	1.0	2.7×10^1	1.0	2.7×10^1
29.4	I-125	2.0×10^1	5.4×10^2	3.0	8.1×10^1
29.5	I-126	2.0	5.4×10^1	1.0	2.7×10^1
29.6	I-129	Unlimited	Unlimited	Unlimited	Unlimited
29.7	I-131	3.0	8.1×10^1	7.0×10^{-1}	1.9×10^1
29.8	I-132	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
29.9	I-133	7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1
29.10	I-134	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
29.11	I-135 ^a	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
29.12	Indium (49)				
29.13	In-111	3.0	8.1×10^1	3.0	8.1×10^1
29.14	In-113m	4.0	1.1×10^2	2.0	5.4×10^1
29.15	In-114m ^a	1.0×10^1	2.7×10^2	5.0×10^{-1}	1.4×10^1
29.16	In-115m	7.0	1.9×10^2	1.0	2.7×10^1
29.17	Iridium (77)				
29.18	Ir-189 ^a	1.0×10^1	2.7×10^2	1.0×10^1	2.7×10^2
29.19	Ir-190	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
29.20	Ir-192 ^c	1.0 ^c	2.7×10^{1c}	6.0×10^{-1}	1.6×10^1
29.21	Ir-194	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
29.22	Potassium (19)				
29.23	K-40	9.0×10^{-1}	2.4×10^1	9.0×10^{-1}	2.4×10^1
29.24	K-42	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
29.25	K-43	7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1
29.26	Krypton (36)				

30.1	<u>Kr-79</u>	<u>4.0</u>	<u>1.1 x 10²</u>	<u>2.0</u>	<u>5.4 x 10¹</u>
30.2	Kr-81	4.0 x 10 ¹	1.1 x 10 ³	4.0 x 10 ¹	1.1 x 10 ³
30.3	Kr-85	1.0 x 10 ¹	2.7 x 10 ²	1.0 x 10 ¹	2.7 x 10 ²
30.4	Kr-85m	8.0	2.2 x 10 ²	3.0	8.1 x 10 ¹
30.5	Kr-87	2.0 x 10 ⁻¹	5.4	2.0 x 10 ⁻¹	5.4
30.6	Lanthanum (57)				
30.7	La-137	3.0 x 10 ¹	8.1 x 10 ²	6.0	1.6 x 10 ²
30.8	La-140	4.0 x 10 ⁻¹	1.1 x 10 ¹	4.0 x 10 ⁻¹	1.1 x 10 ¹
30.9	Lutetium (71)				
30.10	Lu-172	6.0 x 10 ⁻¹	1.6 x 10 ¹	6.0 x 10 ⁻¹	1.6 x 10 ¹
30.11	Lu-173	8.0	2.2 x 10 ²	8.0	2.2 x 10 ²
30.12	Lu-174	9.0	2.4 x 10 ²	9.0	2.4 x 10 ²
30.13	Lu-174m	2.0 x 10 ¹	5.4 x 10 ²	1.0 x 10 ¹	2.7 x 10 ²
30.14	Lu-177	3.0 x 10 ¹	8.1 x 10 ²	7.0 x 10 ⁻¹	1.9 x 10 ¹
30.15	Magnesium (12)				
30.16	Mg-28 ^a	3.0 x 10 ⁻¹	8.1	3.0 x 10 ⁻¹	8.1
30.17	Manganese (25)				
30.18	Mn-52	3.0 x 10 ⁻¹	8.1	3.0 x 10 ⁻¹	8.1
30.19	Mn-53	Unlimited	Unlimited	Unlimited	Unlimited
30.20	Mn-54	1.0	2.7 x 10 ¹	1.0	2.7 x 10 ¹
30.21	Mn-56	3.0 x 10 ⁻¹	8.1	3.0 x 10 ⁻¹	8.1
30.22	Molybdenum (42)				
30.23	Mo-93	4.0 x 10 ¹	1.1 x 10 ³	2.0 x 10 ¹	5.4 x 10 ²
30.24	Mo-99 ^{a,i,h}	1.0	2.7 x 10 ¹	6.0 x 10 ⁻¹	1.6 x 10 ¹

31.1	Nitrogen (7)				
31.2	N-13	9.0×10^{-1}	2.4×10^1	6.0×10^{-1}	1.6×10^1
31.3	Sodium (11)				
31.4	Na-22	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
31.5	Na-24	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
31.6	Niobium (41)				
31.7	Nb-93m	4.0×10^1	1.1×10^3	3.0×10^1	8.1×10^2
31.8	Nb-94	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1
31.9	Nb-95	1.0	2.7×10^1	1.0	2.7×10^1
31.10	Nb-97	9.0×10^{-1}	2.4×10^1	6.0×10^{-1}	1.6×10^1
31.11	Neodymium (60)				
31.12	Nd-147	6.0	1.6×10^2	6.0×10^{-1}	1.6×10^1
31.13	Nd-149	6.0×10^{-1}	1.6×10^1	5.0×10^{-1}	1.4×10^1
31.14	Nickel (28)				
31.15	Ni-59	Unlimited	Unlimited	Unlimited	Unlimited
31.16	Ni-63	4.0×10^1	1.1×10^3	3.0×10^1	8.1×10^2
31.17	Ni-65	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
31.18	Neptunium (93)				
31.19	Np-235	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
31.20	Np-236 (short-lived)	2.0×10^1	5.4×10^2	2.0	5.4×10^1
31.21	Np-236 (long-lived)	9.0×10^0	2.4×10^2	2.0×10^{-2}	5.4×10^{-1}
31.22	Np-237	2.0×10^1	5.4×10^2	2.0×10^{-3}	5.4×10^{-2}
31.23	Np-239	7.0	1.9×10^2	4.0×10^{-1}	1.1×10^1
31.24	Osmium (76)				
31.25	Os-185	1.0	2.7×10^1	1.0	2.7×10^1

32.1	Os-191	1.0×10^1	2.7×10^2	2.0	5.4×10^1
32.2	Os-191m	4.0×10^1	1.1×10^3	3.0×10^1	8.1×10^2
32.3	Os-193	2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1
32.4	Os-194 ^a	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
32.5	Phosphorus (15)				
32.6	P-32	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
32.7	P-33	4.0×10^1	1.1×10^3	1.0	2.7×10^1
32.8	Protactinium (91)				
32.9	Pa-230 ^a	2.0	5.4×10^1	7.0×10^{-2}	1.9
32.10	Pa-231	4.0	1.1×10^2	4.0×10^{-4}	1.1×10^{-2}
32.11	Pa-233	5.0	1.4×10^2	7.0×10^{-1}	1.9×10^1
32.12	Lead (82)				
32.13	Pb-201	1.0	2.7×10^1	1.0	2.7×10^1
32.14	Pb-202	4.0×10^1	1.1×10^3	2.0×10^1	5.4×10^2
32.15	Pb-203	4.0	1.1×10^2	3.0	8.1×10^1
32.16	Pb-205	Unlimited	Unlimited	Unlimited	Unlimited
32.17	Pb-210 ^a	1.0	2.7×10^1	5.0×10^{-2}	1.4
32.18	Pb-212 ^a	7.0×10^{-1}	1.9×10^1	2.0×10^{-1}	5.4
32.19	Palladium (46)				
32.20	Pd-103 ^a	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
32.21	Pd-107	Unlimited	Unlimited	Unlimited	Unlimited
32.22	Pd-109	2.0	5.4×10^1	5.0×10^{-1}	1.4×10^1
32.23	Promethium (61)				
32.24	Pm-143	3.0	8.1×10^1	3.0	8.1×10^1
32.25	Pm-144	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1

33.1	Pm-145	3.0×10^1	8.1×10^2	1.0×10^1	2.7×10^2
33.2	Pm-147	4.0×10^1	1.1×10^3	2.0	5.4×10^1
33.3	Pm-148m ^a	8.0×10^{-1}	2.2×10^1	7.0×10^{-1}	1.9×10^1
33.4	Pm-149	2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1
33.5	Pm-151	2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1
33.6	Polonium (84)				
33.7	Po-210	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}
33.8	Praseodymium (59)				
33.9	Pr-142	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
33.10	Pr-143	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
33.11	Platinum (78)				
33.12	Pt-188 ^a	1.0	2.7×10^1	8.0×10^{-1}	2.2×10^1
33.13	Pt-191	4.0	1.1×10^2	3.0	8.1×10^1
33.14	Pt-193	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
33.15	Pt-193m	4.0×10^1	1.1×10^3	5.0×10^{-1}	1.4×10^1
33.16	Pt-195m	1.0×10^1	2.7×10^2	5.0×10^{-1}	1.4×10^1
33.17	Pt-197	2.0×10^1	5.4×10^2	6.0×10^{-1}	1.6×10^1
33.18	Pt-197m	1.0×10^1	2.7×10^2	6.0×10^{-1}	1.6×10^1
33.19	Plutonium (94)				
33.20	Pu-236	3.0×10^1	8.1×10^2	3.0×10^{-3}	8.1×10^{-2}
33.21	Pu-237	2.0×10^1	5.4×10^2	2.0×10^1	5.4×10^2
33.22	Pu-238	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}
33.23	Pu-239	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}
33.24	Pu-240	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}
33.25	Pu-241 ^a	4.0×10^1	1.1×10^3	6.0×10^{-2}	1.6
33.26	Pu-242	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}

34.1	Pu-244 ^a	4.0×10^{-1}	1.1×10^1	1.0×10^{-3}	2.7×10^{-2}
34.2	Radium (88)				
34.3	Ra-223 ^a	4.0×10^{-1}	1.1×10^1	7.0×10^{-3}	1.9×10^{-1}
34.4	Ra-224 ^a	4.0×10^{-1}	1.1×10^1	2.0×10^{-2}	5.4×10^{-1}
34.5	Ra-225 ^a	2.0×10^{-1}	5.4	4.0×10^{-3}	1.1×10^{-1}
34.6	Ra-226 ^a	2.0×10^{-1}	5.4	3.0×10^{-3}	8.1×10^{-2}
34.7	Ra-228 ^a	6.0×10^{-1}	1.6×10^1	2.0×10^{-2}	5.4×10^{-1}
34.8	Rubidium (37)				
34.9	Rb-81	2.0	5.4×10^1	8.0×10^{-1}	2.2×10^1
34.10	Rb-83 ^a	2.0	5.4×10^1	2.0	5.4×10^1
34.11	Rb-84	1.0	2.7×10^1	1.0	2.7×10^1
34.12	Rb-86	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
34.13	Rb-87	Unlimited	Unlimited	Unlimited	Unlimited
34.14	Rb (nat)	Unlimited	Unlimited	Unlimited	Unlimited
34.15	Rhenium (75)				
34.16	Re-184	1.0	2.7×10^1	1.0	2.7×10^1
34.17	Re-184m	3.0	8.1×10^1	1.0	2.7×10^1
34.18	Re-186	2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1
34.19	Re-187	Unlimited	Unlimited	Unlimited	Unlimited
34.20	Re-188	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
34.21	Re-189 ^a	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
34.22	Re (nat)	Unlimited	Unlimited	Unlimited	Unlimited
34.23	Rhodium (45)				
34.24	Rh-99	2.0	5.4×10^1	2.0	5.4×10^1
34.25	Rh-101	4.0	1.1×10^2	3.0	8.1×10^1

35.1	Rh-102	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
35.2	Rh-102m	2.0	5.4×10^1	2.0	5.4×10^1
35.3	Rh-103m	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
35.4	Rh-105	1.0×10^1	2.7×10^2	8.0×10^{-1}	2.2×10^1
35.5	Radon (86)				
35.6	Rn-222 ^a	3.0×10^{-1}	8.1	4.0×10^{-3}	1.1×10^{-1}
35.7	Ruthenium (44)				
35.8	Ru-97	5.0	1.4×10^2	5.0	1.4×10^2
35.9	Ru-103 ^a	2.0	5.4×10^1	2.0	5.4×10^1
35.10	Ru-105	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
35.11	Ru-106 ^a	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
35.12	Sulphur (16)				
35.13	S-35	4.0×10^1	1.1×10^3	3.0	8.1×10^1
35.14	Antimony (51)				
35.15	Sb-122	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
35.16	Sb-124	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
35.17	Sb-125	2.0	5.4×10^1	1.0	2.7×10^1
35.18	Sb-126	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
35.19	Scandium (21)				
35.20	Sc-44	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
35.21	Sc-46	5.0×10^{-1}	1.4×10^1	5.0×10^{-1}	1.4×10^1
35.22	Sc-47	1.0×10^1	2.7×10^2	7.0×10^{-1}	1.9×10^1
35.23	Sc-48	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
35.24	Selenium (34)				
35.25	Se-75	3.0	8.1×10^1	3.0	8.1×10^1

36.1	Se-79	4.0×10^1	1.1×10^3	2.0	5.4×10^1
36.2	Silicon (14)				
36.3	Si-31	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
36.4	Si-32	4.0×10^1	1.1×10^3	5.0×10^{-1}	1.4×10^1
36.5	Samarium (62)				
36.6	Sm-145	1.0×10^1	2.7×10^2	1.0×10^1	2.7×10^2
36.7	Sm-147	Unlimited	Unlimited	Unlimited	Unlimited
36.8	Sm-151	4.0×10^1	1.1×10^3	1.0×10^1	2.7×10^2
36.9	Sm-153	9.0	2.4×10^2	6.0×10^{-1}	1.6×10^1
36.10	Tin (50)				
36.11	Sn-113 ^a	4.0	1.1×10^2	2.0	5.4×10^1
36.12	Sn-117m	7.0	1.9×10^2	4.0×10^{-1}	1.1×10^1
36.13	Sn-119m	4.0×10^1	1.1×10^3	3.0×10^1	8.1×10^2
36.14	Sn-121m ^a	4.0×10^1	1.1×10^3	9.0×10^{-1}	2.4×10^1
36.15	Sn-123	8.0×10^{-1}	2.2×10^1	6.0×10^{-1}	1.6×10^1
36.16	Sn-125	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
36.17	Sn-126 ^a	6.0×10^{-1}	1.6×10^1	4.0×10^{-1}	1.1×10^1
36.18	Strontium (38)				
36.19	Sr-82 ^a	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
36.20	Sr-85	2.0	5.4×10^1	2.0	5.4×10^1
36.21	Sr-85m	5.0	1.4×10^2	5.0	1.4×10^2
36.22	Sr-87m	3.0	8.1×10^1	3.0	8.1×10^1
36.23	Sr-89	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
36.24	Sr-90 ^a	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
36.25	Sr-91 ^a	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
36.26	Sr-92 ^a	1.0	2.7×10^1	3.0×10^{-1}	8.1

37.1	Tritium (1)				
37.2	T (H-3)	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
37.3	Tantalum (73)				
37.4	Ta-178 (long-lived)	1.0	2.7×10^1	8.0×10^{-1}	2.2×10^1
37.5	Ta-179	3.0×10^1	8.1×10^2	3.0×10^1	8.1×10^2
37.6	Ta-182	9.0×10^{-1}	2.4×10^1	5.0×10^{-1}	1.4×10^1
37.7	Terbium (65)				
37.8	Tb-157	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
37.9	Tb-158	1.0	2.7×10^1	1.0	2.7×10^1
37.10	Tb-160	1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1
37.11	Technetium (43)				
37.12	Tc-95m ^a	2.0	5.4×10^1	2.0	5.4×10^1
37.13	Tc-96	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
37.14	Tc-96m ^a	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1
37.15	Tc-97	Unlimited	Unlimited	Unlimited	Unlimited
37.16	Tc-97m	4.0×10^1	1.1×10^3	1.0	2.7×10^1
37.17	Tc-98	8.0×10^{-1}	2.2×10^1	7.0×10^{-1}	1.9×10^1
37.18	Tc-99	4.0×10^1	1.1×10^3	9.0×10^{-1}	2.4×10^1
37.19	Tc-99m	1.0×10^1	2.7×10^2	4.0	1.1×10^2
37.20	Tellurium (52)				
37.21	Te-121	2.0	5.4×10^1	2.0	5.4×10^1
37.22	Te-121m	5.0	1.4×10^2	3.0	8.1×10^1
37.23	Te-123m	8.0	2.2×10^2	1.0	2.7×10^1
37.24	Te-125m	2.0×10^1	5.4×10^2	9.0×10^{-1}	2.4×10^1
37.25	Te-127	2.0×10^1	5.4×10^2	7.0×10^{-1}	1.9×10^1
37.26	Te-127m ^a	2.0×10^1	5.4×10^2	5.0×10^{-1}	1.4×10^1

38.1	Te-129	7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1
38.2	Te-129m ^a	8.0×10^{-1}	2.2×10^1	4.0×10^{-1}	1.1×10^1
38.3	Te-131m ^a	7.0×10^{-1}	1.9×10^1	5.0×10^{-1}	1.4×10^1
38.4	Te-132 ^a	5.0×10^{-1}	1.4×10^1	4.0×10^{-1}	1.1×10^1
38.5	Thorium (90)				
38.6	Th-227	1.0×10^1	2.7×10^2	5.0×10^{-3}	1.4×10^{-1}
38.7	Th-228 ^a	5.0×10^{-1}	1.4×10^1	1.0×10^{-3}	2.7×10^{-2}
38.8	Th-229	5.0	1.4×10^2	5.0×10^{-4}	1.4×10^{-2}
38.9	Th-230	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}
38.10	Th-231	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}
38.11	Th-232	Unlimited	Unlimited	Unlimited	Unlimited
38.12	Th-234 ^a	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
38.13	Th (nat)	Unlimited	Unlimited	Unlimited	Unlimited
38.14	Titanium (22)				
38.15	Ti-44 ^a	5.0×10^{-1}	1.4×10^1	4.0×10^{-1}	1.1×10^1
38.16	Thallium (81)				
38.17	Tl-200	9.0×10^{-1}	2.4×10^1	9.0×10^{-1}	2.4×10^1
38.18	Tl-201	1.0×10^1	2.7×10^2	4.0	1.1×10^2
38.19	Tl-202	2.0	5.4×10^1	2.0	5.4×10^1
38.20	Tl-204	1.0×10^1	2.7×10^2	7.0×10^{-1}	1.9×10^1
38.21	Thulium (69)				
38.22	Tm-167	7.0	1.9×10^2	8.0×10^{-1}	2.2×10^1
38.23	Tm-170	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
38.24	Tm-171	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3

39.1	Uranium (92)				
39.2	U-230 (fast lung				
39.3	absorption) ^{a,d}	4.0×10^1	1.1×10^3	1.0×10^{-1}	2.7
39.4	U-230 (medium				
39.5	lung absorption) ^{a,e}	4.0×10^1	1.1×10^3	4.0×10^{-3}	1.1×10^{-1}
39.6	U-230 (slow lung				
39.7	absorption) ^{a,f}	3.0×10^1	8.1×10^2	3.0×10^{-3}	8.1×10^{-2}
39.8	U-232 (fast lung				
39.9	absorption) ^d	4.0×10^1	1.1×10^3	1.0×10^{-2}	2.7×10^{-1}
39.10	U-232 (medium				
39.11	lung absorption) ^e	4.0×10^1	1.1×10^3	7.0×10^{-3}	1.9×10^{-1}
39.12	U-232 (slow lung				
39.13	absorption) ^f	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}
39.14	U-233 (fast lung				
39.15	absorption) ^d	4.0×10^1	1.1×10^3	9.0×10^{-2}	2.4
39.16	U-233 (medium				
39.17	lung absorption) ^e	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}
39.18	U-233 (slow lung				
39.19	absorption) ^f	4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}
39.20	U-234 (fast lung				
39.21	absorption) ^d	4.0×10^1	1.1×10^3	9.0×10^{-2}	2.4
39.22	U-234 (medium				
39.23	lung absorption) ^e	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}
39.24	U-234 (slow lung				
39.25	absorption) ^f	4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}
39.26	U-235 (all lung				
39.27	absorption				
39.28	types) ^{a,d,e,f}	Unlimited	Unlimited	Unlimited	Unlimited
39.29	U-236 (fast lung				
39.30	absorption) ^d	Unlimited	Unlimited	Unlimited	Unlimited
39.31	U-236 (medium				
39.32	lung absorption) ^e	4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}

40.1	U-236 (slow lung				
40.2	absorption) ^f	4.0 x 10 ¹	1.1 x 10 ³	6.0 x 10 ⁻³	1.6 x 10 ⁻¹
40.3	U-238 (all lung				
40.4	absorption types) ^{d,e,f}	Unlimited	Unlimited	Unlimited	Unlimited
40.5	U (nat)	Unlimited	Unlimited	Unlimited	Unlimited
40.6	U (enriched to 20%				
40.7	or less) ^g	Unlimited	Unlimited	Unlimited	Unlimited
40.8	U (dep)	Unlimited	Unlimited	Unlimited	Unlimited
40.9	Vanadium (23)				
40.10	V-48	4.0 x 10 ⁻¹	1.1 x 10 ¹	4.0 x 10 ⁻¹	1.1 x 10 ¹
40.11	V-49	4.0 x 10 ¹	1.1 x 10 ³	4.0 x 10 ¹	1.1 x 10 ³
40.12	Tungsten (74)				
40.13	W-178 ^a	9.0	2.4 x 10 ²	5.0	1.4 x 10 ²
40.14	W-181	3.0 x 10 ¹	8.1 x 10 ²	3.0 x 10 ¹	8.1 x 10 ²
40.15	W-185	4.0 x 10 ¹	1.1 x 10 ³	8.0 x 10 ⁻¹	2.2 x 10 ¹
40.16	W-187	2.0	5.4 x 10 ¹	6.0 x 10 ⁻¹	1.6 x 10 ¹
40.17	W-188 ^a	4.0 x 10 ⁻¹	1.1 x 10 ¹	3.0 x 10 ⁻¹	8.1
40.18	Xenon (54)				
40.19	Xe-122 ^a	4.0 x 10 ⁻¹	1.1 x 10 ¹	4.0 x 10 ⁻¹	1.1 x 10 ¹
40.20	Xe-123	2.0	5.4 x 10 ¹	7.0 x 10 ⁻¹	1.9 x 10 ¹
40.21	Xe-127	4.0	1.1 x 10 ²	2.0	5.4 x 10 ¹
40.22	Xe-131m	4.0 x 10 ¹	1.1 x 10 ³	4.0 x 10 ¹	1.1 x 10 ³
40.23	Xe-133	2.0 x 10 ¹	5.4 x 10 ²	1.0 x 10 ¹	2.7 x 10 ²
40.24	Xe-135	3.0	8.1 x 10 ¹	2.0	5.4 x 10 ¹
40.25	Yttrium (39)				
40.26	Y-87 ^a	1.0	2.7 x 10 ¹	1.0	2.7 x 10 ¹
40.27	Y-88	4.0 x 10 ⁻¹	1.1 x 10 ¹	4.0 x 10 ⁻¹	1.1 x 10 ¹

41.1	Y-90	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
41.2	Y-91	6.0×10^{-1}	1.6×10^1	6.0×10^{-1}	1.6×10^1
41.3	Y-91m	2.0	5.4×10^1	2.0	5.4×10^1
41.4	Y-92	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
41.5	Y-93	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
41.6	Ytterbium (70)				
41.7	Yb-169	4.0	1.1×10^2	1.0	2.7×10^1
41.8	Yb-175	3.0×10^1	8.1×10^2	9.0×10^{-1}	2.4×10^1
41.9	Zinc (30)				
41.10	Zn-65	2.0	5.4×10^1	2.0	5.4×10^1
41.11	Zn-69	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
41.12	Zn-69m ^a	3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1
41.13	Zirconium (40)				
41.14	Zr-88	3.0	8.1×10^1	3.0	8.1×10^1
41.15	Zr-93	Unlimited	Unlimited	Unlimited	Unlimited
41.16	Zr-95 ^a	2.0	5.4×10^1	8.0×10^{-1}	2.2×10^1
41.17	Zr-97 ^a	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1

41.18 ^aA₁ and A₂ values include contributions from daughter nuclides with half-lives less than
 41.19 ten days- as listed in the following:

41.20	<u>Mg-28</u>	<u>Al-28</u>
41.21	<u>Ca-47</u>	<u>Sc-47</u>
41.22	<u>Ti-44</u>	<u>Sc-44</u>
41.23	<u>Fe-52</u>	<u>Mn-52m</u>
41.24	<u>Fe-60</u>	<u>Co-60m</u>
41.25	<u>Zn-69m</u>	<u>Zn-69</u>

42.1	<u>Ge-68</u>	<u>Ga-68</u>
42.2	<u>Rb-83</u>	<u>Kr-83m</u>
42.3	<u>Sr-82</u>	<u>Rb-82</u>
42.4	<u>Sr-90</u>	<u>Y-90</u>
42.5	<u>Sr-91</u>	<u>Y-91m</u>
42.6	<u>Sr-92</u>	<u>Y-92</u>
42.7	<u>Y-87</u>	<u>Sr-87m</u>
42.8	<u>Zr-95</u>	<u>Nb-95m</u>
42.9	<u>Zr-97</u>	<u>Nb-97m, Nb-97</u>
42.10	<u>Mo-99</u>	<u>Tc-99m</u>
42.11	<u>Tc-95m</u>	<u>Tc-95</u>
42.12	<u>Tc-96m</u>	<u>Tc-96</u>
42.13	<u>Ru-103</u>	<u>Rh-103m</u>
42.14	<u>Ru-106</u>	<u>Rh-106</u>
42.15	<u>Pd-103</u>	<u>Rh-103m</u>
42.16	<u>Ag-108m</u>	<u>Ag-108</u>
42.17	<u>Ag-110m</u>	<u>Ag-110</u>
42.18	<u>Cd-115</u>	<u>In-115m</u>
42.19	<u>In-114m</u>	<u>In-114</u>
42.20	<u>Sn-113</u>	<u>In-113m</u>
42.21	<u>Sn-121m</u>	<u>Sn-121</u>
42.22	<u>Sn-126</u>	<u>Sb-126m</u>
42.23	<u>Te-127m</u>	<u>Te-127</u>
42.24	<u>Te-129m</u>	<u>Te-129</u>
42.25	<u>Te-131m</u>	<u>Te-131</u>
42.26	<u>Te-132</u>	<u>I-132</u>
42.27	<u>I-135</u>	<u>Xe-135m</u>

43.1	<u>Xe-122</u>	<u>I-122</u>
43.2	<u>Cs-137</u>	<u>Ba-137m</u>
43.3	<u>Ba-131</u>	<u>Cs-131</u>
43.4	<u>Ba-140</u>	<u>La-140</u>
43.5	<u>Ce-144</u>	<u>Pr-144m, Pr-144</u>
43.6	<u>Pm-148M</u>	<u>Pm-148</u>
43.7	<u>Gd-146</u>	<u>Eu-146</u>
43.8	<u>Dy-166</u>	<u>Ho-166</u>
43.9	<u>Hf-172</u>	<u>Lu-172</u>
43.10	<u>W-178</u>	<u>Ta-178</u>
43.11	<u>W-188</u>	<u>Re-188</u>
43.12	<u>Re-189</u>	<u>Os-189m</u>
43.13	<u>Os-194</u>	<u>Ir-194</u>
43.14	<u>Ir-189</u>	<u>Os-189m</u>
43.15	<u>Pt-188</u>	<u>Ir-188</u>
43.16	<u>Hg-194</u>	<u>Au-194</u>
43.17	<u>Hg-195m</u>	<u>Hg-195</u>
43.18	<u>Pb-210</u>	<u>Bi-210</u>
43.19	<u>Pb-212</u>	<u>Bi-212, Tl-208, Po-212</u>
43.20	<u>Bi-210m</u>	<u>Tl-206</u>
43.21	<u>Bi-212</u>	<u>Tl-208, Po-212</u>
43.22	<u>At-211</u>	<u>Po-211</u>
43.23	<u>Rn-222</u>	<u>Po-218, Pb-214, At-218, Bi-214, Po-214</u>
43.24	<u>Ra-223</u>	<u>Rn-219, Po-215, Pb-211, Bi-211, Po-211,</u>
43.25		<u>Tl-207</u>
43.26	<u>Ra-224</u>	<u>Rn-220, Po-216, Pb-212, Bi-212, Tl-208,</u>
43.27		<u>Po-212</u>

44.1	<u>Ra-225</u>	<u>Ac-225, Fr-221, At-217, Bi-213, Tl-209,</u>
44.2		<u>Po-213, Pb-209</u>
44.3	<u>Ra-226</u>	<u>Rn-222, Po-218, Pb-214, At-218, Bi-214,</u>
44.4		<u>Po-214</u>
44.5	<u>Ra-228</u>	<u>Ac-228</u>
44.6	<u>Ac-225</u>	<u>Fr-221, At-217, Bi-213, Tl-209, Po-213,</u>
44.7		<u>Pb-209</u>
44.8	<u>Ac-227</u>	<u>Fr-223</u>
44.9	<u>Th-228</u>	<u>Ra-224, Rn-220, Po-216, Pb-212, Bi-212,</u>
44.10		<u>Tl-208, Po-212</u>
44.11	<u>Th-234</u>	<u>Pa-234m, Pa-234</u>
44.12	<u>Pa-230</u>	<u>Ac-226, Th-226, Fr-222, Ra-222, Rn-218,</u>
44.13		<u>Po-214</u>
44.14	<u>U-230</u>	<u>Th-226, Ra-222, Rn-218, Po-214</u>
44.15	<u>U-235</u>	<u>Th-231</u>
44.16	<u>Pu-241</u>	<u>U-237</u>
44.17	<u>Pu-244</u>	<u>U-240, Np-240m</u>
44.18	<u>Am-242m</u>	<u>Am-242, Np-238</u>
44.19	<u>Am-243</u>	<u>Np-239</u>
44.20	<u>Cm-247</u>	<u>Pu-243</u>
44.21	<u>Bk-249</u>	<u>Am-245</u>
44.22	<u>Cf-253</u>	<u>Cm-249</u>

44.23 ^bThe values of A_1 and A_2 in curies (Ci) are approximate and for information only; the
 44.24 regulatory standard units are Terabecquerels (TBq). See part 4731.0423, subpart 1 -
 44.25 Determination of A_1 and A_2 .

44.26 ^cThe quantity activity of Ir-192 in special form may be determined from a measurement of
 44.27 the rate of decay or a measurement of the radiation level at a prescribed distance from the
 44.28 source.

- 45.1 ^dThese values apply only to compounds of uranium that take the chemical form of UF₆,
 45.2 UO₂F₂, and UO₂(NO₃)₂ in both normal and accident conditions of transport.
- 45.3 ^eThese values apply only to compounds of uranium that take the chemical form of UO₃,
 45.4 UF₄, and UCl₄ and hexavalent compounds in both normal and accident conditions of
 45.5 transport.
- 45.6 ^fThese values apply to all compounds of uranium other than those specified in notes d and
 45.7 e.
- 45.8 ^gThese values apply to unirradiated uranium only.
- 45.9 ^h~~A₁ = 0.1 TBq (2.7 Ci) and A₂ = 0.001 TBq (0.027 Ci) for Cf-252 for domestic use.~~
- 45.10 ^{ih}A₂ = 0.74 TBq (20 Ci) for Mo-99 for domestic use.

45.11 Subp. 2. **Specific activity.** This subpart specifies specific activity for individual
 45.12 radionuclides.

45.13	Element and Atomic		
45.14	Number and Symbol of		Specific Activity
45.15	Radionuclide		
45.16		(TBq/g)	(Ci/g)
45.17	Actinium (89)		
45.18	Ac-225	2.1 x 10 ³	5.8 x 10 ⁴
45.19	Ac-227	2.7	7.2 x 10 ¹
45.20	Ac-228	8.4 x 10 ⁴	2.2 x 10 ⁶
45.21	Silver (47)		
45.22	Ag-105	1.1 x 10 ³	3.0 x 10 ⁴
45.23	Ag-108m	9.7 x 10 ⁻¹	2.6 x 10 ¹
45.24	Ag-110m	1.8 x 10 ²	4.7 x 10 ³
45.25	Ag-111	5.8 x 10 ³	1.6 x 10 ⁵

46.1	Aluminum (13)		
46.2	Al-26	7.0×10^{-4}	1.9×10^{-2}
46.3	Americium (95)		
46.4	Am-241	1.3×10^{-1}	3.4
46.5	Am-242m	3.6×10^{-1}	1.0×10^1
46.6	Am-243	7.4×10^{-3}	2.0×10^{-1}
46.7	Argon (18)		
46.8	Ar-37	3.7×10^3	9.9×10^4
46.9	Ar-39	1.3	3.4×10^1
46.10	Ar-41	1.5×10^6	4.2×10^7
46.11	Ar-42	9.6	2.6×10^2
46.12	Arsenic (33)		
46.13	As-72	6.2×10^4	1.7×10^6
46.14	As-73	8.2×10^2	2.2×10^4
46.15	As-74	3.7×10^3	9.9×10^4
46.16	As-76	5.8×10^4	1.6×10^6
46.17	As-77	3.9×10^4	1.0×10^6
46.18	Astatine (85)		
46.19	At-211	7.6×10^4	2.1×10^6
46.20	Gold (79)		
46.21	Au-193	3.4×10^4	9.2×10^5
46.22	Au-194	1.5×10^4	4.1×10^5
46.23	Au-195	1.4×10^2	3.7×10^3
46.24	Au-196	4.0×10^3	1.1×10^5

47.1	Au-198	9.0×10^3	2.4×10^5
47.2	Au-199	7.7×10^3	2.1×10^5
47.3	Barium (56)		
47.4	Ba-131	3.1×10^3	8.4×10^4
47.5	Ba-133m	2.2×10^4	6.1×10^5
47.6	Ba-133	9.4	2.6×10^2
47.7	Ba-140	2.7×10^3	7.3×10^4
47.8	Beryllium (4)		
47.9	Be-7	1.3×10^4	3.5×10^5
47.10	Be-10	8.3×10^{-4}	2.2×10^{-2}
47.11	Bismuth (83)		
47.12	Bi-205	1.5×10^3	4.2×10^4
47.13	Bi-206	3.8×10^3	1.0×10^5
47.14	Bi-207	1.9	5.2×10^1
47.15	Bi-210m	2.1×10^{-5}	5.7×10^{-4}
47.16	Bi-210	4.6×10^3	1.2×10^5
47.17	Bi-212	5.4×10^5	1.5×10^7
47.18	Berkelium (97)		
47.19	Bk-247	3.8×10^{-2}	1.0
47.20	Bk-249	6.1×10^1	1.6×10^3
47.21	Bromine (35)		
47.22	Br-76	9.4×10^4	2.5×10^6
47.23	Br-77	2.6×10^4	7.1×10^5
47.24	Br-82	4.0×10^4	1.1×10^6

48.1	Carbon (6)		
48.2	C-11	3.1×10^7	8.4×10^8
48.3	C-14	1.6×10^{-1}	4.5
48.4	Calcium (20)		
48.5	Ca-41	3.1×10^{-3}	8.5×10^{-2}
48.6	Ca-45	6.6×10^2	1.8×10^4
48.7	Ca-47	2.3×10^4	6.1×10^5
48.8	Cadmium (48)		
48.9	Cd-109	9.6×10^1	2.6×10^3
48.10	Cd-113m	8.3	2.2×10^2
48.11	Cd-115m	9.4×10^2	2.5×10^4
48.12	Cd-115	1.9×10^4	5.1×10^5
48.13	Cerium (58)		
48.14	Ce-139	2.5×10^2	6.8×10^3
48.15	Ce-141	1.1×10^3	2.8×10^4
48.16	Ce-143	2.5×10^4	6.6×10^5
48.17	Ce-144	1.2×10^2	3.2×10^3
48.18	Californium (98)		
48.19	Cf-248	5.8×10^1	1.6×10^3
48.20	Cf-249	1.5×10^{-1}	4.1
48.21	Cf-250	4.0	1.1×10^2
48.22	Cf-251	5.9×10^{-2}	1.6
48.23	Cf-252	2.0×10^1	5.4×10^2
48.24	Cf-253	1.1×10^3	2.9×10^4
48.25	Cf-254	3.1×10^2	8.5×10^3

49.1	Chlorine (17)		
49.2	Cl-36	1.2×10^{-3}	3.3×10^{-2}
49.3	Cl-38	4.9×10^6	1.3×10^8
49.4	Curium (96)		
49.5	Cm-240	7.5×10^2	2.0×10^4
49.6	Cm-241	6.1×10^2	1.7×10^4
49.7	Cm-242	1.2×10^2	3.3×10^3
49.8	Cm-243	1.9×10^{-3}	5.2×10^1
49.9	Cm-244	3.0	8.1×10^1
49.10	Cm-245	6.4×10^{-3}	1.7×10^{-1}
49.11	Cm-246	1.1×10^{-2}	3.1×10^{-1}
49.12	Cm-247	3.4×10^{-6}	9.3×10^{-5}
49.13	Cm-248	1.6×10^{-4}	4.2×10^{-3}
49.14	Cobalt (27)		
49.15	Co-55	1.1×10^5	3.1×10^6
49.16	Co-56	1.1×10^3	3.0×10^4
49.17	Co-57	3.1×10^2	8.4×10^3
49.18	Co-58m	2.2×10^5	5.9×10^6
49.19	Co-58	1.2×10^3	3.2×10^4
49.20	Co-60	4.2×10^1	1.1×10^3
49.21	Chromium (24)		
49.22	Cr-51	3.4×10^3	9.2×10^4
49.23	Cesium (55)		
49.24	Cs-129	2.8×10^4	7.6×10^5
49.25	Cs-131	3.8×10^3	1.0×10^5
49.26	Cs-132	5.7×10^3	1.5×10^5

50.1	Cs-134m	3.0×10^5	8.0×10^6
50.2	Cs-134	4.8×10^1	1.3×10^3
50.3	Cs-135	4.3×10^{-5}	1.2×10^{-3}
50.4	Cs-136	2.7×10^3	7.3×10^4
50.5	Cs-137	3.2	8.7×10^1
50.6	Copper (29)		
50.7	Cu-64	1.4×10^5	3.9×10^6
50.8	Cu-67	2.8×10^4	7.6×10^5
50.9	Dysprosium (66)		
50.10	Dy-159	2.1×10^2	5.7×10^3
50.11	Dy-165	3.0×10^5	8.2×10^6
50.12	Dy-166	8.6×10^3	2.3×10^5
50.13	Erbium (68)		
50.14	Er-169	3.1×10^3	8.3×10^4
50.15	Er-171	9.0×10^4	2.4×10^6
50.16	Einsteinium (99)		
50.17	Es-253	---	---
50.18	Es-254	---	---
50.19	Es-254m	---	---
50.20	Es-255	---	---
50.21	Europium (63)		
50.22	Eu-147	1.4×10^3	3.7×10^4
50.23	Eu-148	6.0×10^2	1.6×10^4
50.24	Eu-149	3.5×10^2	9.4×10^3
50.25	Eu-150	6.1×10^4	1.6×10^6

51.1	Eu-152m	8.2×10^4	2.2×10^6
51.2	Eu-152	6.5	1.8×10^2
51.3	Eu-154	9.8	2.6×10^2
51.4	Eu-155	1.8×10^1	4.9×10^2
51.5	Eu-156	2.0×10^3	5.5×10^4
51.6	Fluorine (9)		
51.7	F-18	3.5×10^6	9.5×10^7
51.8	Iron (26)		
51.9	Fe-52	2.7×10^5	7.3×10^6
51.10	Fe-55	8.8×10^1	2.4×10^3
51.11	Fe-59	1.8×10^3	5.0×10^4
51.12	Fe-60	7.4×10^{-4}	2.0×10^{-2}
51.13	Fermium (100)		
51.14	Fm-255	---	---
51.15	Fm-257	---	---
51.16	Gallium (31)		
51.17	Ga-67	2.2×10^4	6.0×10^5
51.18	Ga-68	1.5×10^6	4.1×10^7
51.19	Ga-72	1.1×10^5	3.1×10^6
51.20	Gadolinium (64)		
51.21	Gd-146	6.9×10^2	1.9×10^4
51.22	Gd-148	1.2	3.2×10^1
51.23	Gd-153	1.3×10^2	3.5×10^3
51.24	Gd-159	3.9×10^4	1.1×10^6
51.25	Germanium (32)		

52.1	Ge-68	2.6×10^2	7.1×10^3
52.2	Ge-71	5.8×10^3	1.6×10^5
52.3	Ge-77	1.3×10^5	3.6×10^6
52.4	Hydrogen (1)		
52.5	H-3 (T)	3.6×10^2	9.7×10^3
52.6	Hafnium (72)		
52.7	Hf-172	4.1×10^1	1.1×10^3
52.8	Hf-175	3.9×10^2	1.1×10^4
52.9	Hf-181	6.3×10^2	1.7×10^4
52.10	Hf-182	8.1×10^{-6}	2.2×10^{-4}
52.11	Mercury (80)		
52.12	Hg-194	1.3×10^{-1}	3.5
52.13	Hg-195m	1.5×10^4	4.0×10^5
52.14	Hg-197m	2.5×10^4	6.7×10^5
52.15	Hg-197	9.2×10^3	2.5×10^5
52.16	Hg-203	5.1×10^2	1.4×10^4
52.17	Holmium (67)		
52.18	Ho-163	2.7	7.6×10^1
52.19	Ho-166m	6.6×10^{-2}	1.8
52.20	Ho-166	2.6×10^4	7.0×10^5
52.21	Iodine (53)		
52.22	I-123	7.1×10^4	1.9×10^6
52.23	I-124	9.3×10^3	2.5×10^5
52.24	I-125	6.4×10^2	1.7×10^4
52.25	I-126	2.9×10^3	8.0×10^4

53.1	I-129	6.5×10^{-6}	1.8×10^{-4}
53.2	I-131	4.6×10^3	1.2×10^5
53.3	I-132	3.8×10^5	1.0×10^7
53.4	I-133	4.2×10^4	1.1×10^6
53.5	I-134	9.9×10^5	2.7×10^7
53.6	I-135	1.3×10^5	3.5×10^6
53.7	Indium (49)		
53.8	In-111	1.5×10^4	4.2×10^5
53.9	In-113m	6.2×10^5	1.7×10^7
53.10	In-114m	8.6×10^2	2.3×10^4
53.11	In-115m	2.2×10^5	6.1×10^6
53.12	Iridium (77)		
53.13	Ir-189	1.9×10^3	5.2×10^4
53.14	Ir-190	2.3×10^3	6.2×10^4
53.15	Ir-192	3.4×10^2	9.2×10^3
53.16	Ir-193m	2.4×10^3	6.4×10^4
53.17	Ir-194	3.1×10^4	8.4×10^5
53.18	Potassium (19)		
53.19	K-40	2.4×10^{-7}	6.4×10^{-6}
53.20	K-42	2.2×10^5	6.0×10^6
53.21	K-43	1.2×10^5	3.3×10^6
53.22	Krypton (36)		
53.23	<u>Kr-79</u>	<u>4.2×10^4</u>	<u>1.1×10^6</u>
53.24	Kr-81	7.8×10^{-4}	2.1×10^{-2}
53.25	Kr-85m	3.0×10^5	8.2×10^6
53.26	Kr-85	1.5×10^1	3.9×10^2

54.1	Kr-87	1.0×10^6	2.8×10^7
54.2	Lanthanum (57)		
54.3	La-137	1.6×10^{-3}	4.4×10^{-2}
54.4	La-140	2.1×10^4	5.6×10^5
54.5	Lutetium (71)		
54.6	Lu-172	4.2×10^3	1.1×10^5
54.7	Lu-173	5.6×10^1	1.5×10^3
54.8	Lu-174m	2.0×10^2	5.3×10^3
54.9	Lu-174	2.3×10^1	6.2×10^2
54.10	Lu-177	4.1×10^3	1.1×10^5
54.11	Magnesium (12)		
54.12	Mg-28	2.0×10^5	5.4×10^6
54.13	Manganese (25)		
54.14	Mn-52	1.6×10^4	4.4×10^5
54.15	Mn-53	6.8×10^{-5}	1.8×10^{-3}
54.16	Mn-54	2.9×10^2	7.7×10^3
54.17	Mn-56	8.0×10^5	2.2×10^7
54.18	Molybdenum (42)		
54.19	Mo-93	4.1×10^{-2}	1.1
54.20	Mo-99	1.8×10^4	4.8×10^5
54.21	Nitrogen (7)		
54.22	N-13	5.4×10^7	1.5×10^9
54.23	Sodium (11)		
54.24	Na-22	2.3×10^2	6.3×10^3
54.25	Na-24	3.2×10^5	8.7×10^6

55.1	Niobium (41)		
55.2	Nb-92m	5.2×10^3	1.4×10^5
55.3	Nb-93m	8.8	2.4×10^2
55.4	Nb-94	6.9×10^{-3}	1.9×10^{-1}
55.5	Nb-95	1.5×10^3	3.9×10^4
55.6	Nb-97	9.9×10^5	2.7×10^7
55.7	Neodymium (60)		
55.8	Nd-147	3.0×10^3	8.1×10^4
55.9	Nd-149	4.5×10^5	1.2×10^7
55.10	Nickel (28)		
55.11	Ni-59	3.0×10^{-3}	8.0×10^{-2}
55.12	Ni-63	2.1	5.7×10^1
55.13	Ni-65	7.1×10^5	1.9×10^7
55.14	Neptunium (93)		
55.15	Np-235	5.2×10^1	1.4×10^3
55.16	Np-236	4.7×10^{-4}	1.3×10^{-2}
55.17	Np-237	2.6×10^{-5}	7.1×10^{-4}
55.18	Np-239	8.6×10^3	2.3×10^5
55.19	Osmium (76)		
55.20	Os-185	2.8×10^2	7.5×10^3
55.21	Os-191m	4.6×10^4	1.3×10^6
55.22	Os-191	1.6×10^3	4.4×10^4
55.23	Os-193	2.0×10^4	5.3×10^5
55.24	Os-194	1.1×10^1	3.1×10^2

56.1	Phosphorus (15)		
56.2	P-32	1.1×10^4	2.9×10^5
56.3	P-33	5.8×10^3	1.6×10^5
56.4	Protactinium (91)		
56.5	Pa-230	1.2×10^3	3.3×10^4
56.6	Pa-231	1.7×10^{-3}	4.7×10^{-2}
56.7	Pa-233	7.7×10^2	2.1×10^4
56.8	Lead (82)		
56.9	Pb-201	6.2×10^4	1.7×10^6
56.10	Pb-202	1.2×10^{-4}	3.4×10^{-3}
56.11	Pb-203	1.1×10^4	3.0×10^5
56.12	Pb-205	4.5×10^{-6}	1.2×10^{-4}
56.13	Pb-210	2.8	7.6×10^1
56.14	Pb-212	5.1×10^4	1.4×10^6
56.15	Palladium (46)		
56.16	Pd-103	2.8×10^3	7.5×10^4
56.17	Pd-107	1.9×10^{-5}	5.1×10^{-4}
56.18	Pd-109	7.9×10^4	2.1×10^6
56.19	Promethium (61)		
56.20	Pm-143	1.3×10^2	3.4×10^3
56.21	Pm-144	9.2×10^1	2.5×10^3
56.22	Pm-145	5.2	1.4×10^2
56.23	Pm-147	3.4×10^1	9.3×10^2
56.24	Pm-148m	7.9×10^2	2.1×10^4
56.25	Pm-149	1.5×10^4	4.0×10^5
56.26	Pm-151	2.7×10^4	7.3×10^5

57.1	Polonium (84)		
57.2	Po-208	2.2×10^1	5.9×10^2
57.3	Po-209	6.2×10^{-1}	1.7×10^1
57.4	Po-210	1.7×10^2	4.5×10^3
57.5	Praseodymium (59)		
57.6	Pr-142	4.3×10^4	1.2×10^6
57.7	Pr-143	2.5×10^3	6.7×10^4
57.8	Platinum (78)		
57.9	Pt-188	2.5×10^3	6.8×10^4
57.10	Pt-191	8.7×10^3	2.4×10^5
57.11	Pt-193m	5.8×10^3	1.6×10^5
57.12	Pt-193	1.4	3.7×10^1
57.13	Pt-195m	6.2×10^3	1.7×10^5
57.14	Pt-197m	3.7×10^5	1.0×10^7
57.15	Pt-197	3.2×10^4	8.7×10^5
57.16	Plutonium (94)		
57.17	Pu-236	2.0×10^1	5.3×10^2
57.18	Pu-237	4.5×10^2	1.2×10^4
57.19	Pu-238	6.3×10^{-1}	1.7×10^1
57.20	Pu-239	2.3×10^{-3}	6.2×10^{-2}
57.21	Pu-240	8.4×10^{-3}	2.3×10^{-1}
57.22	Pu-241	3.8	1.0×10^2
57.23	Pu-242	1.5×10^{-4}	3.9×10^{-3}
57.24	Pu-244	6.7×10^{-7}	1.8×10^{-5}
57.25	Radium (88)		
57.26	Ra-223	1.9×10^3	5.1×10^4

58.1	Ra-224	5.9×10^3	1.6×10^5
58.2	Ra-225	1.5×10^3	3.9×10^4
58.3	Ra-226	3.7×10^{-2}	1.0
58.4	Ra-228	1.0×10^1	2.7×10^2
58.5	Rubidium (37)		
58.6	Rb-81	3.1×10^5	8.4×10^6
58.7	Rb-83	6.8×10^2	1.8×10^4
58.8	Rb-84	1.8×10^3	4.7×10^4
58.9	Rb-86	3.0×10^3	8.1×10^4
58.10	Rb-87	3.2×10^{-9}	8.6×10^{-8}
58.11	Rb (natural)	6.7×10^6	1.8×10^8
58.12	Rhenium (75)		
58.13	Re-183	3.8×10^2	1.0×10^4
58.14	Re-184m	1.6×10^2	4.3×10^3
58.15	Re-184	6.9×10^2	1.9×10^4
58.16	Re-186	6.9×10^3	1.9×10^5
58.17	Re-187	1.4×10^{-9}	3.8×10^{-8}
58.18	Re-188	3.6×10^4	9.8×10^5
58.19	Re-189	2.5×10^4	6.8×10^5
58.20	Re (natural)	---	2.4×10^{-8}
58.21	Rhodium (45)		
58.22	Rh-99	3.0×10^3	8.2×10^4
58.23	Rh-101	4.1×10^1	1.1×10^3
58.24	Rh-102m	2.3×10^2	6.2×10^3
58.25	Rh-102	4.5×10^1	1.2×10^3
58.26	Rh-103m	1.2×10^6	3.3×10^7

59.1	Rh-105	3.1×10^4	8.4×10^5
59.2	Radon (86)		
59.3	Rn-222	5.7×10^3	1.5×10^5
59.4	Ruthenium (44)		
59.5	Ru-97	1.7×10^4	4.6×10^5
59.6	Ru-103	1.2×10^3	3.2×10^4
59.7	Ru-105	2.5×10^5	6.7×10^6
59.8	Ru-106	1.2×10^2	3.3×10^3
59.9	Sulfur (16)		
59.10	S-35	1.6×10^3	4.3×10^4
59.11	Antimony (51)		
59.12	Sb-122	1.5×10^4	4.0×10^5
59.13	Sb-124	6.5×10^2	1.7×10^4
59.14	Sb-125	3.9×10^1	1.0×10^3
59.15	Sb-126	3.1×10^3	8.4×10^4
59.16	Scandium (21)		
59.17	Sc-44	6.7×10^5	1.8×10^7
59.18	Sc-46	1.3×10^3	3.4×10^4
59.19	Sc-47	3.1×10^4	8.3×10^5
59.20	Sc-48	5.5×10^4	1.5×10^6
59.21	Selenium (34)		
59.22	Se-75	5.4×10^2	1.5×10^4
59.23	Se-79	2.6×10^{-3}	7.0×10^{-2}
59.24	Silicon (14)		
59.25	Si-31	1.4×10^6	3.9×10^7

60.1	Si-32	3.9	1.1×10^2
60.2	Samarium (62)		
60.3	Sm-145	9.8×10^1	2.6×10^3
60.4	Sm-147	8.5×10^{-1}	2.3×10^{-8}
60.5	Sm-151	9.7×10^{-1}	2.6×10^1
60.6	Sm-153	1.6×10^4	4.4×10^5
60.7	Tin (50)		
60.8	Sn-113	3.7×10^2	1.0×10^4
60.9	Sn-117m	3.0×10^3	8.2×10^4
60.10	Sn-119m	1.4×10^2	3.7×10^3
60.11	Sn-121m	2.0	5.4×10^1
60.12	Sn-123	3.0×10^2	8.2×10^3
60.13	Sn-125	4.0×10^3	1.1×10^5
60.14	Sn-126	1.0×10^{-3}	2.8×10^{-2}
60.15	Strontium (38)		
60.16	Sr-82	2.3×10^3	6.2×10^4
60.17	Sr-85m	1.2×10^6	3.3×10^7
60.18	Sr-85	8.8×10^2	2.4×10^4
60.19	Sr-87m	4.8×10^5	1.3×10^7
60.20	Sr-89	1.1×10^3	2.9×10^4
60.21	Sr-90	5.1	1.4×10^2
60.22	Sr-91	1.3×10^5	3.6×10^6
60.23	Sr-92	4.7×10^5	1.3×10^7
60.24	Tritium (1)		
60.25	T (H-3)	3.6×10^2	9.7×10^3

61.1	Tantalum (73)		
61.2	Ta-178	4.2×10^6	1.1×10^8
61.3	Ta-179	4.1×10^1	1.1×10^3
61.4	Ta-182	2.3×10^2	6.2×10^3
61.5	Terbium (65)		
61.6	Tb-157	5.6×10^{-1}	1.5×10^1
61.7	Tb-158	5.6×10^{-1}	1.5×10^1
61.8	Tb-160	4.2×10^2	1.1×10^4
61.9	Technetium (43)		
61.10	Tc-95m	8.3×10^2	2.2×10^4
61.11	Tc-96m	1.4×10^6	3.8×10^7
61.12	Tc-96	1.2×10^4	3.2×10^5
61.13	Tc-97m	5.6×10^2	1.5×10^4
61.14	Tc-97	5.2×10^{-5}	1.4×10^{-3}
61.15	Tc-98	3.2×10^{-5}	8.7×10^{-4}
61.16	Tc-99m	1.9×10^5	5.3×10^6
61.17	Tc-99	6.3×10^{-4}	1.7×10^{-2}
61.18	Tellurium (52)		
61.19	Te-118	6.8×10^3	1.8×10^5
61.20	Te-121m	2.6×10^2	7.0×10^3
61.21	Te-121	2.4×10^3	6.4×10^4
61.22	Te-123m	3.3×10^2	8.9×10^3
61.23	Te-125m	6.7×10^2	1.8×10^4
61.24	Te-127m	3.5×10^2	9.4×10^3
61.25	Te-127	9.8×10^4	2.6×10^6
61.26	Te-129m	1.1×10^3	3.0×10^4

62.1	Te-129	7.7×10^5	2.1×10^7
62.2	Te-131m	3.0×10^4	8.0×10^5
62.3	Te-132	1.1×10^4	3.0×10^5
62.4	Thorium (90)		
62.5	Th-227	1.1×10^3	3.1×10^4
62.6	Th-228	3.0×10^1	8.2×10^2
62.7	Th-229	7.9×10^{-3}	2.1×10^{-1}
62.8	Th-230	7.6×10^{-4}	2.1×10^{-2}
62.9	Th-231	2.0×10^4	5.3×10^5
62.10	Th-232	4.0×10^{-9}	1.1×10^{-7}
62.11	Th-234	8.6×10^2	2.3×10^4
62.12	Th (natural)	8.1×10^{-9}	2.2×10^{-7}
62.13	Titanium (22)		
62.14	Ti-44	6.4	1.7×10^2
62.15	Thallium (81)		
62.16	Tl-200	2.2×10^4	6.0×10^5
62.17	Tl-201	7.9×10^3	2.1×10^5
62.18	Tl-202	2.0×10^3	5.3×10^4
62.19	Tl-204	1.7×10^1	4.6×10^2
62.20	Thulium (69)		
62.21	Tm-167	3.1×10^3	8.5×10^4
62.22	Tm-168	3.1×10^2	8.3×10^3
62.23	Tm-170	2.2×10^2	6.0×10^3
62.24	Tm-171	4.0×10^1	1.1×10^3

63.1	Uranium (92)		
63.2	U-230	1.0×10^3	2.7×10^4
63.3	U-232	8.3×10^{-1}	2.2×10^1
63.4	U-233	3.6×10^{-4}	9.7×10^{-3}
63.5	U-234	2.3×10^{-4}	6.2×10^{-3}
63.6	U-235	8.0×10^{-8}	2.2×10^{-6}
63.7	U-236	2.4×10^{-6}	6.5×10^{-5}
63.8	U-238	1.2×10^{-8}	3.4×10^{-7}
63.9	U (natural)	2.6×10^{-8}	7.1×10^{-7}
63.10	U (enriched 5% or less)	---	(See part 4731.0424)
63.11	U (enriched more than 5%)	---	(See part 4731.0424)
63.12	U (depleted)	---	(See part 4731.0424)
63.13	Vanadium (23)		
63.14	V-48	6.3×10^3	1.7×10^5
63.15	V-49	3.0×10^2	8.1×10^3
63.16	Tungsten (74)		
63.17	W-178	1.3×10^3	3.4×10^4
63.18	W-181	2.2×10^2	6.0×10^3
63.19	W-185	3.5×10^2	9.4×10^3
63.20	W-187	2.6×10^4	7.0×10^5
63.21	W-188	3.7×10^2	1.0×10^4
63.22	Xenon (54)		
63.23	Xe-122	4.8×10^4	1.3×10^6
63.24	Xe-123	4.4×10^5	1.2×10^7
63.25	Xe-127	1.0×10^3	2.8×10^4
63.26	Xe-131m	3.1×10^3	8.4×10^4

64.1	Xe-133	6.9×10^3	1.9×10^5
64.2	Xe-135	9.5×10^4	2.6×10^6
64.3	Yttrium (39)		
64.4	Y-87	1.7×10^4	4.5×10^5
64.5	Y-88	5.2×10^2	1.4×10^4
64.6	Y-90	2.0×10^4	5.4×10^5
64.7	Y-91m	1.5×10^6	4.2×10^7
64.8	Y-91	9.1×10^2	2.5×10^4
64.9	Y-92	3.6×10^5	9.6×10^6
64.10	Y-93	1.2×10^5	3.3×10^6
64.11	Ytterbium (70)		
64.12	Yb-169	8.9×10^2	2.4×10^4
64.13	Yb-175	6.6×10^3	1.8×10^5
64.14	Zinc (30)		
64.15	Zn-65	3.0×10^2	8.2×10^3
64.16	Zn-69m	1.2×10^5	3.3×10^6
64.17	Zn-69	1.8×10^6	4.9×10^7
64.18	Zirconium (40)		
64.19	Zr-88	6.6×10^2	1.8×10^4
64.20	Zr-93	9.3×10^{-5}	2.5×10^{-3}
64.21	Zr-95	7.9×10^2	2.1×10^4
64.22	Zr-97	7.1×10^4	1.9×10^6

- 64.23 Subp. 3. **Exempt material activity concentrations and exempt consignment activity**
- 64.24 **limits.** This subpart specifies exempt material activity concentrations and exempt
- 64.25 consignment activity levels for radionuclides.

65.1	Element and atomic	Activity	Activity	Activity limit for	Activity limit for
65.2	number and symbol	concentration for	concentration for	exempt	exempt
65.3	of radionuclide	exempt material	exempt material	consignment	consignment
65.4		(Bq/g)	(Ci/g)	(Bq)	(Ci)
65.5	Actinium (89)				
65.6	Ac-225	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
65.7	Ac-227	1.0×10^{-1}	2.7×10^{-12}	1.0×10^3	2.7×10^{-8}
65.8	Ac-228	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
65.9	Silver (47)				
65.10	Ag-105	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
65.11	Ag-108m ^a	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
65.12	Ag-110m	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
65.13	Ag-111	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
65.14	Aluminum (13)				
65.15	Al-26	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
65.16	Americium (95)				
65.17	Am-241	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
65.18	Am-242m ^a	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
65.19	Am-243 ^a	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
65.20	Argon (18)				
65.21	Ar-37	1.0×10^6	2.7×10^{-5}	1.0×10^8	2.7×10^{-3}
65.22	Ar-39	1.0×10^7	2.7×10^{-4}	1.0×10^4	2.7×10^{-7}
65.23	Ar-41	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}
65.24	Arsenic (33)				
65.25	As-72	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
65.26	As-73	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}

66.1	As-74	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
66.2	As-76	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
66.3	As-77	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
66.4	Astatine (85)				
66.5	At-211	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
66.6	Gold (79)				
66.7	Au-193	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
66.8	Au-194	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
66.9	Au-195	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
66.10	Au-198	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
66.11	Au-199	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
66.12	Barium (56)				
66.13	Ba-131	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
66.14	Ba-133	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
66.15	Ba-133m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
66.16	Ba-140 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
66.17	Beryllium (4)				
66.18	Be-7	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
66.19	Be-10	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
66.20	Bismuth (83)				
66.21	Bi-205	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
66.22	Bi-206	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
66.23	Bi-207	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
66.24	Bi-210	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
66.25	Bi-210m	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}

67.1	Bi-212 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
67.2	Berkelium (97)				
67.3	Bk-247	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
67.4	Bk-249	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
67.5	Bromine (35)				
67.6	Br-76	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
67.7	Br-77	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
67.8	Br-82	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
67.9	Carbon(6)				
67.10	C-11	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
67.11	C-14	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
67.12	Calcium (20)				
67.13	Ca-41	1.0×10^5	2.7×10^{-6}	1.0×10^7	2.7×10^{-4}
67.14	Ca-45	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
67.15	Ca-47	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
67.16	Cadmium (48)				
67.17	Cd-109	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
67.18	Cd-113m	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
67.19	Cd-115	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
67.20	Cd-115m	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
67.21	Cerium (58)				
67.22	Ce-139	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
67.23	Ce-141	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
67.24	Ce-143	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
67.25	Ce-144 ^a	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}

68.1	Californium (98)				
68.2	Cf-248	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
68.3	Cf-249	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.4	Cf-250	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
68.5	Cf-251	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.6	Cf-252	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
68.7	Cf-253	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
68.8	Cf-254	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.9	Chlorine (17)				
68.10	Cl-36	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
68.11	Cl-38	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
68.12	Curium (96)				
68.13	Cm-240	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
68.14	Cm-241	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
68.15	Cm-242	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
68.16	Cm-243	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
68.17	Cm-244	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
68.18	Cm-245	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.19	Cm-246	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.20	Cm-247	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
68.21	Cm-248	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
68.22	Cobalt (27)				
68.23	Co-55	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
68.24	Co-56	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
68.25	Co-57	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
68.26	Co-58	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}

69.1	Co-58m	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
69.2	Co-60	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
69.3	Chromium (24)				
69.4	Cr-51	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
69.5	Cesium (55)				
69.6	Cs-129	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
69.7	Cs-131	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
69.8	Cs-132	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
69.9	Cs-134	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
69.10	Cs-134m	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}
69.11	Cs-135	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
69.12	Cs-136	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
69.13	Cs-137 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
69.14	Copper (29)				
69.15	Cu-64	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
69.16	Cu-67	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
69.17	Dysprosium (66)				
69.18	Dy-159	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
69.19	Dy-165	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
69.20	Dy-166	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
69.21	Erbium (68)				
69.22	Er-169	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
69.23	Er-171	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
69.24	Europium (63)				
69.25	Eu-147	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}

70.1	Eu-148	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.2	Eu-149	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
70.3	Eu-150 (short-lived)	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
70.4	Eu-150 (long-lived)	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.5	Eu-152	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.6	Eu-152m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
70.7	Eu-154	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.8	Eu-155	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
70.9	Eu-156	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.10	Fluorine (9)				
70.11	F-18	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.12	Iron (26)				
70.13	Fe-52	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.14	Fe-55	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
70.15	Fe-59	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.16	Fe-60	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
70.17	Gallium (31)				
70.18	Ga-67	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
70.19	Ga-68	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
70.20	Ga-72	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
70.21	Gadolinium (64)				
70.22	Gd-146	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
70.23	Gd-148	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
70.24	Gd-153	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
70.25	Gd-159	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}

71.1	Germanium (32)				
71.2	Ge-68	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
71.3	Ge-71	1.0×10^4	2.7×10^{-7}	1.0×10^8	2.7×10^{-3}
71.4	Ge-77	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
71.5	Tritium (1)				
71.6	H-3 (T)	1.0×10^6	2.7×10^{-5}	1.0×10^9	2.7×10^{-2}
71.7	Hafnium (72)				
71.8	Hf-172	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
71.9	Hf-175	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
71.10	Hf-181	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
71.11	Hf-182	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
71.12	Mercury (80)				
71.13	Hg-194	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
71.14	Hg-195m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
71.15	Hg-197	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
71.16	Hg-197m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
71.17	Hg-203	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
71.18	Holmium (67)				
71.19	Ho-166	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}
71.20	Ho-166m	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
71.21	Iodine (53)				
71.22	I-123	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
71.23	I-124	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
71.24	I-125	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
71.25	I-126	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}

72.1	I-129	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
72.2	I-131	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.3	I-132	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
72.4	I-133	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
72.5	I-134	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
72.6	I-135	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
72.7	Indium (49)				
72.8	In-111	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.9	In-113m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.10	In-114m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.11	In-115m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.12	Iridium (77)				
72.13	Ir-189	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
72.14	Ir-190	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
72.15	Ir-192	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
72.16	Ir-194	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
72.17	Potassium (19)				
72.18	K-40	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.19	K-42	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
72.20	K-43	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
72.21	Krypton (36)				
72.22	<u>Kr-79</u>	<u>1.0×10^3</u>	<u>2.7×10^{-8}</u>	<u>1.0×10^5</u>	<u>2.7×10^{-6}</u>
72.23	Kr-81	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
72.24	Kr-85	1.0×10^5	2.7×10^{-6}	1.0×10^4	2.7×10^{-7}
72.25	Kr-85m	1.0×10^3	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
72.26	Kr-87	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}

73.1	Lanthanum (57)				
73.2	La-137	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
73.3	La-140	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
73.4	Lutetium (71)				
73.5	Lu-172	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
73.6	Lu-173	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
73.7	Lu-174	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
73.8	Lu-174m	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
73.9	Lu-177	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
73.10	Magnesium (12)				
73.11	Mg-28	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
73.12	Manganese (25)				
73.13	Mn-52	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
73.14	Mn-53	1.0×10^4	2.7×10^{-7}	1.0×10^9	2.7×10^{-2}
73.15	Mn-54	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
73.16	Mn-56	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
73.17	Molybdenum (42)				
73.18	Mo-93	1.0×10^3	2.7×10^{-8}	1.0×10^8	2.7×10^{-3}
73.19	Mo-99	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
73.20	Nitrogen (7)				
73.21	N-13	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}
73.22	Sodium (11)				
73.23	Na-22	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
73.24	Na-24	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
73.25	Niobium (41)				

74.1	Nb-93m	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
74.2	Nb-94	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
74.3	Nb-95	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
74.4	Nb-97	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
74.5	Neodymium (60)				
74.6	Nd-147	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
74.7	Nd-149	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
74.8	Nickel (28)				
74.9	Ni-59	1.0×10^4	2.7×10^{-7}	1.0×10^8	2.7×10^{-3}
74.10	Ni-63	1.0×10^5	2.7×10^{-6}	1.0×10^8	2.7×10^{-3}
74.11	Ni-65	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
74.12	Neptunium (93)				
74.13	Np-235	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
74.14	Np-236 (short-lived)	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
74.15	Np-236 (long-lived)	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
74.16	Np-237 ^a	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
74.17	Np-239	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
74.18	Osmium (76)				
74.19	Os-185	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
74.20	Os-191	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
74.21	Os-191m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
74.22	Os-193	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
74.23	Os-194	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
74.24	Phosphorus (15)				
74.25	P-32	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}

75.1	P-33	1.0×10^5	2.7×10^{-6}	1.0×10^8	2.7×10^{-3}
75.2	Protactinium (91)				
75.3	Pa-230	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
75.4	Pa-231	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
75.5	Pa-233	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
75.6	Lead (82)				
75.7	Pb-201	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
75.8	Pb-202	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
75.9	Pb-203	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
75.10	Pb-205	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
75.11	Pb-210 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
75.12	Pb-212 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
75.13	Palladium (46)				
75.14	Pd-103	1.0×10^3	2.7×10^{-8}	1.0×10^8	2.7×10^{-3}
75.15	Pd-107	1.0×10^5	2.7×10^{-6}	1.0×10^8	2.7×10^{-3}
75.16	Pd-109	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
75.17	Promethium (61)				
75.18	Pm-143	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
75.19	Pm-144	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
75.20	Pm-145	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
75.21	Pm-147	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
75.22	Pm-148m	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
75.23	Pm-149	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
75.24	Pm-151	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
75.25	Polonium (84)				

76.1	Po-210	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
76.2	Praseodymium (59)				
76.3	Pr-142	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
76.4	Pr-143	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
76.5	Platinum (78)				
76.6	Pt-188	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
76.7	Pt-191	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
76.8	Pt-193	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
76.9	Pt-193m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
76.10	Pt-195m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
76.11	Pt-197	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
76.12	Pt-197m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
76.13	Plutonium (94)				
76.14	Pu-236	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
76.15	Pu-237	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
76.16	Pu-238	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
76.17	Pu-239	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
76.18	Pu-240	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
76.19	Pu-241	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
76.20	Pu-242	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
76.21	Pu-244	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
76.22	Radium (88)				
76.23	Ra-223 ^a	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
76.24	Ra-224 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
76.25	Ra-225	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
76.26	Ra-226 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}

77.1	Ra-228 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
77.2	Rubidium (37)				
77.3	Rb-81	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
77.4	Rb-83	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
77.5	Rb-84	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
77.6	Rb-86	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
77.7	Rb-87	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
77.8	Rb (nat)	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
77.9	Rhenium (75)				
77.10	Re-184	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
77.11	Re-184m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
77.12	Re-186	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
77.13	Re-187	1.0×10^6	2.7×10^{-5}	1.0×10^9	2.7×10^{-2}
77.14	Re-188	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
77.15	Re-189	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
77.16	Re (nat)	1.0×10^6	2.7×10^{-5}	1.0×10^9	2.7×10^{-2}
77.17	Rhodium (45)				
77.18	Rh-99	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
77.19	Rh-101	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
77.20	Rh-102	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
77.21	Rh-102m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
77.22	Rh-103m	1.0×10^4	2.7×10^{-7}	1.0×10^8	2.7×10^{-3}
77.23	Rh-105	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
77.24	Radon (86)				
77.25	Rn-222 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^8	2.7×10^{-3}

78.1	Ruthenium (44)				
78.2	Ru-97	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
78.3	Ru-103	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
78.4	Ru-105	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
78.5	Ru-106 ^a	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
78.6	Sulfur (16)				
78.7	S-35	1.0×10^5	2.7×10^{-6}	1.0×10^8	2.7×10^{-3}
78.8	Antimony (51)				
78.9	Sb-122	1.0×10^2	2.7×10^{-9}	1.0×10^4	2.7×10^{-7}
78.10	Sb-124	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
78.11	Sb-125	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
78.12	Sb-126	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
78.13	Scandium (21)				
78.14	Sc-44	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
78.15	Sc-46	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
78.16	Sc-47	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
78.17	Sc-48	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
78.18	Selenium (34)				
78.19	Se-75	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
78.20	Se-79	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
78.21	Silicon (14)				
78.22	Si-31	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
78.23	Si-32	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
78.24	Samarium (62)				
78.25	Sm-145	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}

79.1	Sm-147	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
79.2	Sm-151	1.0×10^4	2.7×10^{-7}	1.0×10^8	2.7×10^{-3}
79.3	Sm-153	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
79.4	Tin (50)				
79.5	Sn-113	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
79.6	Sn-117m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
79.7	Sn-119m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
79.8	Sn-121m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
79.9	Sn-123	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
79.10	Sn-125	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
79.11	Sn-126	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
79.12	Strontium (38)				
79.13	Sr-82	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
79.14	Sr-85	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
79.15	Sr-85m	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
79.16	Sr-87m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
79.17	Sr-89	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
79.18	Sr-90 ^a	1.0×10^2	2.7×10^{-9}	1.0×10^4	2.7×10^{-7}
79.19	Sr-91	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
79.20	Sr-92	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
79.21	Tritium (1)				
79.22	T (H-3)	1.0×10^6	2.7×10^{-5}	1.0×10^9	2.7×10^{-2}
79.23	Tantalum (73)				
79.24	Ta-178 (long-lived)	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
79.25	Ta-179	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
79.26	Ta-182	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}

80.1	Terbium (65)				
80.2	Tb-157	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
80.3	Tb-158	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.4	Tb-160	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.5	Technetium (43)				
80.6	Tc-95m	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.7	Tc-96	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.8	Tc-96m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
80.9	Tc-97	1.0×10^3	2.7×10^{-8}	1.0×10^8	2.7×10^{-3}
80.10	Tc-97m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
80.11	Tc-98	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.12	Tc-99	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
80.13	Tc-99m	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
80.14	Tellurium (52)				
80.15	Te-121	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.16	Te-121m	1.0×10^2	2.7×10^{-9}	$1.0 \times 10^{\underline{56}}$	$2.7 \times 10^{\underline{6-5}}$
80.17	Te-123m	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
80.18	Te-125m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
80.19	Te-127	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
80.20	Te-127m	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
80.21	Te-129	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
80.22	Te-129m	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
80.23	Te-131m	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
80.24	Te-132	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}
80.25	Thorium (90)				
80.26	Th-227	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}

81.1	Th-228 ^a	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
81.2	Th-229 ^a	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
81.3	Th-230	1.0	2.7×10^{-11}	1.0×10^4	2.7×10^{-7}
81.4	Th-231	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
81.5	Th-232	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
81.6	Th-234 ^a	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}
81.7	Th (nat) ^a	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
81.8	Titanium (22)				
81.9	Ti-44	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
81.10	Thallium (81)				
81.11	Tl-200	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
81.12	Tl-201	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
81.13	Tl-202	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
81.14	Tl-204	1.0×10^4	2.7×10^{-7}	1.0×10^4	2.7×10^{-7}
81.15	Thulium (69)				
81.16	Tm-167	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
81.17	Tm-170	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
81.18	Tm-171	1.0×10^4	2.7×10^{-7}	1.0×10^8	2.7×10^{-3}
81.19	Uranium (92)				
81.20	U-230 (fast lung				
81.21	absorption) ^{a,b}	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
81.22	U-230 (medium				
81.23	lung absorption) ^c	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
81.24	U-230 (slow lung				
81.25	absorption) ^d	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
81.26	U-232 (fast lung				
81.27	absorption) ^{a,b}	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}

82.1	U-232 (medium				
82.2	lung absorption) ^c	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.3	U-232 (slow lung				
82.4	absorption) ^d	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.5	U-233 (fast lung				
82.6	absorption) ^b	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.7	U-233 (medium				
82.8	lung absorption) ^c	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
82.9	U-233 (slow lung				
82.10	absorption) ^d	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
82.11	U-234 (fast lung				
82.12	absorption) ^b	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.13	U-234 (medium				
82.14	lung absorption) ^c	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
82.15	U-234 (slow lung				
82.16	absorption) ^d	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
82.17	U-235 (all lung				
82.18	absorption				
82.19	types) ^{a,b,c,d}	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.20	U-236 (fast lung				
82.21	absorption) ^b	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.22	U-236 (medium				
82.23	lung absorption) ^c	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
82.24	U-236 (slow lung				
82.25	absorption) ^d	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.26	U-238 (all lung				
82.27	absorption				
82.28	types) ^{a,b,c,d}	1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
82.29	U (nat) ^a	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
82.30	U (enriched to 20%				
82.31	or less) ^e	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
82.32	U (dep)	1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}

83.1	Vanadium (23)				
83.2	V-48	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
83.3	V-49	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
83.4	Tungsten (74)				
83.5	W-178	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
83.6	W-181	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
83.7	W-185	1.0×10^4	2.7×10^{-7}	1.0×10^7	2.7×10^{-4}
83.8	W-187	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
83.9	W-188	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
83.10	Xenon (54)				
83.11	Xe-122	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}
83.12	Xe-123	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}
83.13	Xe-127	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}
83.14	Xe-131m	1.0×10^4	2.7×10^{-7}	1.0×10^4	2.7×10^{-7}
83.15	Xe-133	1.0×10^3	2.7×10^{-8}	1.0×10^4	2.7×10^{-7}
83.16	Xe-135	1.0×10^3	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
83.17	Yttrium (39)				
83.18	Y-87	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
83.19	Y-88	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
83.20	Y-90	1.0×10^3	2.7×10^{-8}	1.0×10^5	2.7×10^{-6}
83.21	Y-91	1.0×10^3	2.7×10^{-8}	1.0×10^6	2.7×10^{-5}
83.22	Y-91m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
83.23	Y-92	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
83.24	Y-93	1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
83.25	Ytterbium (70)				
83.26	Yb-169	1.0×10^2	2.7×10^{-9}	1.0×10^7	2.7×10^{-4}

84.1	Yb-175	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
84.2	Zinc (30)				
84.3	Zn-65	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
84.4	Zn-69	1.0×10^4	2.7×10^{-7}	1.0×10^6	2.7×10^{-5}
84.5	Zn-69m	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
84.6	Zirconium (40)				
84.7	Zr-88	1.0×10^2	2.7×10^{-9}	1.0×10^6	2.7×10^{-5}
84.8	Zr-93 ^a	1.0×10^3	2.7×10^{-8}	1.0×10^7	2.7×10^{-4}
84.9	Zr-95	1.0×10^1	2.7×10^{-10}	1.0×10^6	2.7×10^{-5}
84.10	Zr-97 ^a	1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}

84.11 ^aParent nuclides and their progeny included in secular equilibrium are listed in the following
 84.12 as follows:

84.13	Sr-90	Y-90
84.14	Zr-93	Nb-93m
84.15	Zr-97	Nb-97
84.16	Ru-106	Rh-106
84.17	<u>Ag-108m</u>	<u>Ag-108</u>
84.18	Cs-137	Ba-137m
84.19	Ce-134	La-134
84.20	Ce-144	Pr-144
84.21	Ba-140	La-140
84.22	Bi-212	Tl-208(0.36), Po-212(0.64)
84.23	Pb-210	Bi-210, Po-210
84.24	Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
84.25	Rn-220	Po-216
84.26	Rn-222	Po-218, Pb-214, Bi-214, Po-214

85.1	Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
85.2	Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
85.3	Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
85.4	Ra-228	Ac-228
85.5	Th-226	Ra-222, Rn-218, Po-214
85.6	Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
85.7	Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
85.8	Th (nat)	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212,
85.9		Tl-208 (0.36), Po-212 (0.64)
85.10	Th-234	Pa-234m
85.11	U-230	Th-226, Ra-222, Rn-218, Po-214
85.12	U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36),
85.13		Po-212 (0.64)
85.14	U-235	Th-231
85.15	U-238	Th-234, Pa-234m
85.16	U (nat)	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214,
85.17		Bi-214, Po-214, Pb-210, Bi-210, Po-210
85.18	U-240	Np-240m
85.19	Np-237	Pa-233
85.20	Am-242m	Am-242
85.21	Am-243	Np-239

85.22 ^bThese values apply only to compounds of uranium that take the chemical form of UF₆,
85.23 UO₂F₂ and UO₂(NO₃)₂ in both normal and accident conditions of transport.

85.24 ^cThese values apply only to compounds of uranium that take the chemical form of UO₃,
85.25 UF₄, UCl₄ and hexavalent compounds in both normal and accident conditions of transport.

85.26 ^dThese values apply to all compounds of uranium other than those specified in notes b and
85.27 c of this table.

85.28 ^eThese values apply to unirradiated uranium only.

86.1 **4731.0423 DETERMINATION OF A₁ AND A₂.**86.2 [For text of subps 1 to 3, see M.R.]86.3 Subp. 4. **Radionuclide mixture.** For mixtures of radionuclides whose identities and
86.4 respective activities are known, the following conditions apply:86.5 A. For special form radioactive material, the maximum quantity transported in a
86.6 Type A package:

$$\sum_i \frac{B(i)}{A_1(i)} \leq 1$$

86.7 where B(i) is the activity of radionuclide i in special form and A₁(i) is the A₁ value for
86.8 radionuclide i.86.9 B. For normal form radioactive material, the maximum quantity transported in a
86.10 Type A package:

$$\sum_i \frac{B(i)}{A_2(i)} \leq 1$$

86.11 where B(i) is the activity of radionuclide i in normal form and A₂(i) is the A₂ value for
86.12 radionuclide i.86.13 C. If the package contains both a special and normal form radioactive material,
86.14 the activity that may be transported in a Type A package:

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

86.15 where B(i) is the activity of radionuclide i in special form, A₁(i) is the A₁ value for
86.16 radionuclide i, C(j) is the activity of radionuclide j in normal form, and A₂(j) is the A₂ value
86.17 for radionuclide j.

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

$$A_1 \text{ for mixture} = \frac{1}{\sum_i \frac{f(i)}{A_1(i)}}$$

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

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

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

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

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

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

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

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

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

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

88.3 **Subp. 5. Activities unknown.**

88.4 A. When the identity of each radionuclide is known, but the individual activities
88.5 of some of the radionuclides are not known, the radionuclides may be grouped and the
88.6 lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in
88.7 applying the formulas in subpart 4. Groups may be based on the total alpha activity and the
88.8 total beta/gamma activity when these are known, using the lowest A_1 or A_2 values for the
88.9 alpha emitters and beta/gamma emitters.

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

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

	A_1		A_2	
Contents	(TBq)	(Ci)	(TBq)	(Ci)
88.20 Only beta- or 88.21 gamma-emitting 88.22 radionuclides are 88.23 known to be present	1×10^{-1}	2.7×10^0	2×10^{-2}	5.4×10^{-1}
88.24 Only alpha-emitting 88.25 radionuclides are 88.26 known to be present 88.27 <u>Alpha-emitting nuclides,</u>	2×10^{-1}	5.4×10^0	9×10^{-5}	2.4×10^{-3}

89.1 but no neutron emitters are
89.2 known to be present^a

89.3 ~~No relevant data are~~
89.4 ~~available~~ Neutron-emitting
89.5 nuclides are known to be
89.6 present or no relevant data
89.7 are available

1×10^{-3}

2.7×10^{-2}

9×10^{-5}

2.4×10^{-3}

89.8 ^a If beta- or gamma-emitting nuclides are known to be present, the A₁ value of 0.1 TBq (2.7
89.9 Ci) should be used.

	Activity			
	concentration	Activity	Activity limits	Activity limits
	for exempt	concentration	for exempt	for exempt
	material	for exempt	consignments	consignments
89.14	Contents	material	(Bq)	(Ci)
	(Bq/g)	material (Ci/g)	(Bq)	(Ci)

89.15 Only beta- or
89.16 gamma-emitting
89.17 radionuclides are
89.18 known to be present

1×10^1

2.7×10^{-10}

1×10^4

2.7×10^{-7}

89.19 ~~Only alpha-emitting~~
89.20 ~~radionuclides are~~
89.21 ~~known to be present~~
89.22 Alpha-emitting nuclides,
89.23 but no neutron emitters are
89.24 known to be present^a

1×10^{-1}

2.7×10^{-12}

1×10^3

2.7×10^{-8}

89.25 No relevant data are
89.26 available

1×10^{-1}

2.7×10^{-12}

1×10^3

2.7×10^{-8}

89.27 Neutron-emitting nuclides
89.28 are known to be present or
89.29 no relevant data are
89.30 available

1×10^{-1}

2.7×10^{-12}

1×10^3

2.7×10^{-8}

89.31 ^a If beta- or gamma-emitting nuclides are known to be present, the A₁ value of 0.1 TBq (2.7
89.32 Ci) should be used.

90.1 **4731.0580 APPLICATION; FINANCIAL ASSURANCE AND RECORD KEEPING**
90.2 **FOR DECOMMISSIONING.**

90.3 Subpart 1. **Requirements.**

90.4 A. An applicant for a specific license authorizing possession and use of unsealed
90.5 special nuclear material in quantities exceeding 10^5 times the applicable quantities under
90.6 part 4731.3160 must submit a decommissioning funding plan according to subpart 4. A
90.7 decommissioning funding plan must also be submitted when a combination of isotopes is
90.8 involved if R divided by 10^5 is greater than 1 (unity rule), where R is the sum of the ratios
90.9 of the quantity of each isotope to the applicable value in part 4731.3160.

90.10 ~~A. B.~~ An applicant for a specific license authorizing possession and use of unsealed
90.11 special nuclear material in quantities specified in subpart 3 must:

90.12 (1) submit a decommissioning funding plan according to subpart 4; or

90.13 (2) submit a certification that financial assurance for decommissioning has
90.14 been provided in the amount prescribed under subpart 3, using one of the methods described
90.15 in subpart 5. The certification may state that the appropriate assurance will be obtained after
90.16 the application has been approved and the license issued, but before the receipt of licensed
90.17 material.

90.18 ~~B. C.~~ If an applicant defers execution of the financial instrument until after the
90.19 license has been issued, a signed original of the financial instrument obtained to satisfy the
90.20 requirements of subpart 5 must be submitted to the commissioner before receipt of licensed
90.21 material.

90.22 ~~C. D.~~ If the applicant does not defer execution of the financial instrument, the
90.23 applicant must submit to the commissioner, as part of the certification, a signed original of
90.24 the financial instrument obtained to satisfy the requirements of subpart 5.

90.25 [For text of subp 2, see M.R.]

91.1 Subp. 3. **Financial assurance; amounts.** The following amounts of financial assurance
91.2 are required for decommissioning by quantity of material:

91.3 Greater than 10^4 but less than or equal to 10^5 times the applicable
91.4 quantities under part 4731.3160. For a combination of isotopes, if
91.5 R, as defined in ~~Code of Federal Regulations, title 10, section 70.25,~~
91.6 ~~paragraph (a) subpart 1, item A,~~ divided by 10^4 is greater than 1
91.7 but R divided by 10^5 is less than or equal to 1. \$1,125,000

91.8 Greater than 10^3 but less than or equal to 10^4 times the applicable
91.9 quantities under part 4731.3160. For a combination of isotopes, if
91.10 R, as defined in ~~Code of Federal Regulations, title 10, section 70.25,~~
91.11 ~~paragraph (a) subpart 1, item A,~~ divided by 10^3 is greater than 1
91.12 but R divided by 10^4 is less than or equal to 1. \$225,000

91.13 [For text of subs 4 to 6, see M.R.]

91.14 **4731.0610 AUTHORIZED USE OF SPECIAL NUCLEAR MATERIAL.**

91.15 Subpart 1. **Authority under license.** A licensee must confine the licensee's possession
91.16 and use of special nuclear material to the locations and purposes authorized in the license.
91.17 Except as otherwise provided in the license, a license issued under this chapter carries with
91.18 it the right to receive title to, own, acquire, receive, possess, and use special nuclear material.
91.19 Preparation for shipment and transport of special nuclear material must be according to
91.20 parts 4731.0400 to ~~4731.0455~~ 4731.0424.

91.21 [For text of subp 2, see M.R.]

91.22 **4731.0620 REPORTING REQUIREMENTS.**

91.23 [For text of subs 1 and 2, see M.R.]

91.24 Subp. 3. **Preparation and submission of reports.**

91.25 [For text of item A, see M.R.]

92.1 B. A licensee that makes a report required under subpart 1 or 2 ~~or Code of Federal~~
92.2 ~~Regulations, title 10, section 70.74, and part 70, Appendix A, if applicable,~~ must submit a
92.3 written follow-up report within 30 days of the initial notification. Written reports prepared
92.4 as required by other rules may be submitted to fulfill this requirement if the reports contain
92.5 all of the necessary information. The written reports must be sent to the commissioner. The
92.6 reports must include:

92.7 [For text of subitems (1) to (6), see M.R.]

92.8 **4731.2600 REPORTS; THEFT OR LOSS OF LICENSED MATERIAL.**

92.9 Subpart 1. **Telephone reports.**

92.10 ~~A.~~ A licensee must report to the commissioner by telephone, according to part
92.11 4731.0200, as follows:

92.12 A. ~~(1)~~ immediately after its occurrence becomes known to the licensee, any lost,
92.13 stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000
92.14 times the quantity under part 4731.2800, under such circumstances that it appears to the
92.15 licensee that an exposure could result to persons in unrestricted areas; or

92.16 B. ~~(2)~~ within 30 days after an occurrence of any lost, stolen, or missing licensed
92.17 material becomes known to the licensee, all licensed material in a quantity greater than ten
92.18 times the quantity under part 4731.2800 that is still missing at the time of the report.

92.19 ~~B. Licensees having an installed emergency notification system must make reports~~
92.20 ~~to the NRC Operations Center according to Code of Federal Regulations, title 10, section~~
92.21 ~~50.72, the commissioner, and the state duty officer at 1-800-422-0798, according to part~~
92.22 ~~4731.0200. All other licensees must make reports by telephone to the state duty officer at~~
92.23 ~~1-800-422-0798.~~

92.24 [For text of subp 2, see M.R.]

93.1 Subp. 3. [See repealer.]

93.2 [For text of subps 4 and 5, see M.R.]

93.3 **4731.2610 NOTIFICATION OF INCIDENTS.**

93.4 [For text of subps 1 to 3, see M.R.]

93.5 Subp. 4. **Reporting method.** Licensees ~~having an installed emergency notification~~
93.6 ~~system~~ must make the reports required under this part to the ~~NRC Operations Center~~
93.7 ~~according to Code of Federal Regulations, title 10, section 50.72. All other licensees must~~
93.8 ~~make the reports required under this part by telephone to the commissioner or state duty~~
93.9 ~~officer at 1-800-422-0798~~ according to part 4731.0200.

93.10 [For text of subp 5, see M.R.]

93.11 **4731.3030 EXEMPTION; CERTAIN ITEMS CONTAINING RADIOACTIVE**
93.12 **MATERIAL.**

93.13 Subpart 1. **Exempt products.** Except for persons who apply radioactive material to
93.14 or incorporate radioactive material into the following products or persons who initially
93.15 transfer for sale or distribution the following products containing radioactive material, a
93.16 person is exempt from parts 4731.3000 to 4731.7280 to the extent that the person receives,
93.17 possesses, uses, transfers, owns, or acquires the following products:

93.18 [For text of item A, see M.R.]

93.19 B. (1) static elimination devices which contain, as a sealed source or sources,
93.20 by-product material consisting of a total of not more than 18.5 MBq (500 µCi) of
93.21 polonium-210 per device;

93.22 [For text of subitem (2), see M.R.]

93.23 (3) devices in subitems (1) and (2) authorized before December 31, 2014,
93.24 for use under ~~the a general license then provided in part 4731.3210 and equivalent regulations~~

94.1 ~~of the NRC or agreement states and~~, that were manufactured, tested, and labeled by the
94.2 manufacturer in accordance with the specifications contained in a specific license issued
94.3 by the commissioner, the NRC, or an agreement state.

94.4 [For text of items C to G, see M.R.]

94.5 [For text of subp 2, see M.R.]

94.6 **4731.3065 SPECIFIC LICENSES; APPLICATION.**

94.7 Subpart 1. **General requirements.**

94.8 [For text of item A, see M.R.]

94.9 ~~B. The applicant may incorporate by reference information contained in previous~~
94.10 ~~applications, statements, or reports filed with the commissioner, provided the references~~
94.11 ~~are clear and specific.~~

94.12 ~~€. B.~~ An application must be signed by the applicant or licensee or a person duly
94.13 authorized to act for and on behalf of the applicant or licensee.

94.14 ~~Ð. C.~~ The commissioner may at any time after the filing of the original application,
94.15 and before the expiration of the license, require further statements to enable the commissioner
94.16 to determine whether the application should be granted or denied or whether a license should
94.17 be modified or revoked.

94.18 ~~E. An application for a license under this part shall be considered also as an~~
94.19 ~~application for licenses authorizing other activities for which licenses are required by the~~
94.20 ~~commissioner, provided that the application specifies the additional activities for which~~
94.21 ~~licenses are requested and complies with requirements for applications for such licenses.~~

94.22 ~~F. D.~~ An application must be accompanied by the fee prescribed under Minnesota
94.23 Statutes, section 144.1205.

95.1 ~~G. E.~~ An application for a license to receive and possess radioactive material that
95.2 the commissioner has determined will significantly affect the quality of the environment
95.3 must be filed at least nine months prior to commencement of construction of the plant or
95.4 facility in which the activity will be conducted and must be accompanied by any
95.5 environmental report as required under Code of Federal Regulations, title 10, part 51, subpart
95.6 A.

95.7 [For text of subps 2 to 7, see M.R.]

95.8 **4731.3075 TERMS AND CONDITIONS OF LICENSES.**

95.9 [For text of subps 1 and 2, see M.R.]

95.10 Subp. 3. **Scope of license.** A person licensed by the commissioner under this chapter
95.11 must confine the licensee's possession and use of radioactive material to the locations and
95.12 purposes authorized in the license. Except as otherwise provided in the license, a license
95.13 issued under parts 4731.3000 to 4731.7280 carries with it the right to receive, acquire, own,
95.14 and possess radioactive material. Preparation for shipment and transport of radioactive
95.15 material must be according to parts 4731.0400 to ~~4731.0455~~ 4731.0424.

95.16 [For text of subps 4 to 9, see M.R.]

95.17 **4731.3085 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.**

95.18 Subpart 1. **Expiration.**

95.19 A. ~~Except as provided under item C,~~ A specific license expires at the end of the
95.20 day on the expiration date stated in the license, unless the licensee has filed an application
95.21 for renewal under part 4731.3090 not less than 30 days before the expiration date stated in
95.22 the existing license ~~or, for licenses under item C, 30 days before the deemed expiration date~~
95.23 ~~according to item C.~~

95.24 B. If an application for renewal has been filed at least 30 days before the expiration
95.25 date stated in the existing license, ~~or 30 days before the deemed expiration date under item~~

96.1 ~~€~~, the existing license expires at the end of the day on which the commissioner makes a
 96.2 final determination to deny the renewal application or, if the determination states an
 96.3 expiration date, the expiration date stated in the determination.

96.4 ~~C. A specific license that has an expiration date after July 1, 1995, and is not one~~
 96.5 ~~of the licenses described in item D, is deemed to have an expiration date that is five years~~
 96.6 ~~after the expiration date stated in the current license.~~

96.7 ~~D. The following specific licenses are not subject to, or otherwise affected by,~~
 96.8 ~~item C:~~

96.9 ~~(1) a specific license for which, on February 15, 1996, an evaluation or an~~
 96.10 ~~emergency plan is required according to part 4731.3065, subpart 4, item A;~~

96.11 ~~(2) a specific license whose holder is subject to the financial assurance~~
 96.12 ~~requirements under part 4731.3080, and on February 15, 1996, the holder:~~

96.13 ~~(a) has not submitted a decommissioning funding plan or certification~~
 96.14 ~~of financial assurance for decommissioning; or~~

96.15 ~~(b) has not received written notice that the decommissioning funding~~
 96.16 ~~plan or certification of financial assurance for decommissioning is acceptable; and~~

96.17 ~~(3) a specific license whose holder is on the list of contaminated sites~~
 96.18 ~~maintained for the NRC's site decommissioning management plan (SDMP) and published~~
 96.19 ~~in Site Decommissioning Management Plan, NUREG-1444, Supplement 1 (November~~
 96.20 ~~1995).~~

96.21 [For text of subps 2 to 4, see M.R.]

96.22 **4731.3395 SPECIFIC LICENSE; RADIOACTIVE DRUGS FOR MEDICAL USE;**
 96.23 **MANUFACTURE, PREPARATION, OR TRANSFER.**

96.24 [For text of subp 1, see M.R.]

97.1 Subp. 2. **Pharmacy licensees.**

97.2 [For text of items A and B, see M.R.]

97.3 C. A licensee described in subpart 1, item B, subitem (3) or (4), may designate a
97.4 pharmacist as an authorized nuclear pharmacist if the individual was a nuclear pharmacist
97.5 preparing only radioactive drugs containing accelerator-produced radioactive material, and
97.6 the individual practiced at a pharmacy at a government agency or federally recognized
97.7 Indian ~~tribe~~ Tribes before November 30, 2007, or at all other pharmacies before August 8,
97.8 2009, or an earlier date as noticed by the NRC.

97.9 D. No later than 30 days after the date that a licensee described in subpart 1, item
97.10 B, subitem (3) or (4), allows an individual to work as an authorized nuclear pharmacist
97.11 under item A, subitem (2), unit (a) or (c), the licensee must provide to the commissioner a
97.12 copy of:

97.13 [For text of subitems (1) and (2), see M.R.]

97.14 (3) documentation that only accelerator-produced radioactive materials were
97.15 used in the practice of nuclear pharmacy at a government agency or federally recognized
97.16 Indian ~~tribe~~ Tribes before November 30, 2007, or at all other pharmacies before August 8,
97.17 2009, or an earlier date as noticed by the NRC; and

97.18 [For text of subitem (4), see M.R.]

97.19 [For text of subps 3 and 4, see M.R.]

97.20 **4731.4030 PERFORMANCE REQUIREMENTS; INDUSTRIAL RADIOGRAPHY**
97.21 **EQUIPMENT.**

97.22 Subpart 1. **ANSI standard.**

97.23 [For text of item A, see M.R.]

98.1 B. A radiographic exposure device, source assembly, or sealed source and all
98.2 associated equipment must meet the requirements specified in American National Standard
98.3 N432, "Radiological Safety for the Design and Construction of Apparatus for Gamma
98.4 Radiography," American National Standards Institute (ANSI) (1981). The ANSI standard
98.5 is incorporated by reference, is not subject to frequent change, and is available through the
98.6 ~~Minutex interlibrary loan~~ MnLink system. This publication may be purchased from the
98.7 American National Standards Institute, Inc., 25 West 43rd Street, New York, NY 10036;
98.8 telephone: (212) 642-4900.

98.9 [For text of item C, see M.R.]

98.10 Subp. 2. **Additional requirements.**

98.11 [For text of items A and B, see M.R.]

98.12 C. Radiographic exposure devices intended for use as Type B transport containers
98.13 must meet the applicable requirements under parts 4731.0400 to ~~4731.0455~~ 4731.0424.

98.14 [For text of item D, see M.R.]

98.15 [For text of subps 3 and 4, see M.R.]

98.16 **4731.4110 LABELING; PACKAGING; SECURITY.**

98.17 [For text of subp 1, see M.R.]

98.18 Subp. 2. **Required packaging.** A licensee may not transport licensed material unless
98.19 the material is packaged, and the package is labeled, marked, and accompanied with
98.20 appropriate shipping papers, according to parts 4731.0400 to ~~4731.0455~~ 4731.0424.

98.21 [For text of subps 3 and 4, see M.R.]

98.22 **4731.4140 RADIOGRAPHER TRAINING.**

98.23 Subpart 1. **Requirements; radiographer.** A licensee may not permit an individual
98.24 to act as a radiographer until the individual:

99.1 [For text of items A to C, see M.R.]

99.2 D. receives copies of and instruction in parts 4731.0200, 4731.0280, and
99.3 4731.0290; the applicable DOT regulations under parts 4731.0400 to ~~4731.0455~~ 4731.0424;
99.4 the applicable portions of parts 4731.1000 to 4731.2950; parts 4731.4000 to 4731.4360;
99.5 the license under which the radiographer will perform industrial radiography; and the
99.6 licensee's operating and emergency procedures;

99.7 [For text of items E to G, see M.R.]

99.8 Subp. 2. **Requirements; radiographer's assistant.** A licensee may not permit an
99.9 individual to act as a radiographer's assistant until the individual:

99.10 A. receives copies of and instruction in parts 4731.0200, 4731.0280, and
99.11 4731.0290; the applicable DOT regulations under parts 4731.0400 to ~~4731.0455~~ 4731.0424;
99.12 the applicable portions of parts 4731.1000 to 4731.2950; parts 4731.4000 to 4731.4360;
99.13 the license under which the radiographer's assistant will perform industrial radiography;
99.14 and the licensee's operating and emergency procedures;

99.15 [For text of items B and C, see M.R.]

99.16 [For text of subps 3 to 7, see M.R.]

99.17 **4731.7050 LABELS, SECURITY, AND TRANSPORTATION PRECAUTIONS.**

99.18 Subpart 1. **Labeling.**

99.19 [For text of items A and B, see M.R.]

99.20 C. A licensee may not transport licensed material unless the material is packaged,
99.21 labeled, marked, and accompanied with appropriate shipping papers according to parts
99.22 4731.0400 to ~~4731.0455~~ 4731.0424.

99.23 [For text of subp 2, see M.R.]

100.1 **4731.8025 REQUIREMENTS FOR CRIMINAL HISTORY RECORDS CHECKS**
100.2 **OF INDIVIDUALS GRANTED UNESCORTED ACCESS TO CATEGORY 1 OR**
100.3 **CATEGORY 2 QUANTITIES OF RADIOACTIVE MATERIAL.**

100.4 [For text of subps 1 and 2, see M.R.]

100.5 **Subp. 3. Procedures for processing of fingerprint checks.**

100.6 A. For the purpose of complying with parts 4731.8010 to 4731.8040, licensees
100.7 must submit to the ~~Office of Administration~~ U.S. Nuclear Regulatory Commission, Director,
100.8 Division of Facilities and Security, Mail Stop TWB-05 B32M, U.S. Nuclear Regulatory
100.9 Commission, Washington, DC 20555-0012 11545 Rockville Pike, ATTN: Criminal History
100.10 Program/Mail Stop TWB-05 B32M, Rockville, MD 20852-2738, one completed, legible
100.11 standard fingerprint card (Form FD-258, ORIMDNRCOOOZ), electronic fingerprint scan
100.12 or, where practicable, other fingerprint record for each individual requiring unescorted
100.13 access to category 1 or category 2 quantities of radioactive material. Copies of these forms
100.14 may be obtained by writing the ~~Office of Information Services~~ Office of the Chief
100.15 Information Officer, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001,
100.16 by calling ~~(301) 415-7232~~ (630) 829-9565, or by e-mail to FORMS.Resource@nrc.gov.
100.17 Guidance on submitting electronic fingerprints can be found at
100.18 <http://www.nrc.gov/site-help/e-submittals.html>.

100.19 [For text of items B and C, see M.R.]

100.20 **4731.8030 RELIEF FROM FINGERPRINTING, IDENTIFICATION, AND**
100.21 **CRIMINAL HISTORY RECORDS CHECKS AND OTHER ELEMENTS OF**
100.22 **BACKGROUND INVESTIGATIONS.**

100.23 **Subpart 1. Exemption to certain security checks.** Fingerprinting, and the identification
100.24 and criminal history records checks required by section 149 of the Atomic Energy Act of
100.25 1954, as amended, and other elements of the background investigation are not required for
100.26 the following individuals prior to granting unescorted access to category 1 or category 2
100.27 quantities of radioactive materials:

101.1 [For text of items A to I, see M.R.]

101.2 J. commercial vehicle drivers for road shipments of category 1 and category 2
101.3 quantities of radioactive material;

101.4 [For text of items K to M, see M.R.]

101.5 [For text of subp 2, see M.R.]

101.6 **4731.8100 ADDITIONAL REQUIREMENTS FOR TRANSFER OF CATEGORY**
101.7 **1 AND CATEGORY 2 QUANTITIES OF RADIOACTIVE MATERIAL.**

101.8 A licensee transferring a category 1 or category 2 quantity of radioactive material to a
101.9 licensee of the commissioner, the NRC, or an agreement state must meet the license
101.10 verification provisions of this part instead of those listed in part 4731.3105, subpart 3.

101.11 A. Any licensee transferring category 1 quantities of radioactive material to a
101.12 licensee of the ~~commission~~ commissioner, the NRC, or an agreement state, prior to
101.13 conducting ~~such~~ the transfer, must verify with the NRC's license verification system or the
101.14 license-issuing authority that the transferee's license authorizes the receipt of the type, form,
101.15 and quantity of radioactive material to be transferred and that the licensee is authorized to
101.16 receive radioactive material at the location requested for delivery. If the verification is
101.17 conducted by contacting the license-issuing authority, the transferor must document the
101.18 verification. For transfers within the same organization, the licensee does not need to verify
101.19 the transfer.

101.20 B. Any licensee transferring category 2 quantities of radioactive material to a
101.21 licensee of the commissioner, the NRC, or an agreement state, prior to conducting ~~such~~ the
101.22 transfer, must verify with the NRC's license verification system or the license-issuing
101.23 authority that the transferee's license authorizes the receipt of the type, form, and quantity
101.24 of radioactive material to be transferred. If the verification is conducted by contacting the

102.1 license-issuing authority, the transferor must document the verification. For transfers within
102.2 the same organization, the licensee does not need to verify the transfer.

102.3 [For text of items C and D, see M.R.]

102.4 **4731.8115 ADVANCE NOTIFICATION OF SHIPMENT OF CATEGORY 1**
102.5 **QUANTITIES OF RADIOACTIVE MATERIAL.**

102.6 [For text of subp 1, see M.R.]

102.7 **Subp. 2. Procedures for submitting advance notification.**

102.8 A. The notification must be made to the commissioner and to the office of each
102.9 appropriate governor or governor's designee. The contact information, including telephone
102.10 numbers and mailing addresses, of governors and governors' designees, is available on the
102.11 NRC Web site at ~~http://nrc-stp.ornl.gov/special/designee.pdf~~
102.12 http://scp.nrc.gov/special/designee.pdf. A list of the contact information is also available
102.13 upon request from the Director, ~~Division of Intergovernmental Liaison and Rulemaking,~~
102.14 ~~Office of Federal and State Materials and Environmental Management Programs~~ Division
102.15 of Material Safety, State, Tribal, and Rulemaking Programs, Office of Nuclear Material
102.16 Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555.
102.17 Notifications to the commissioner must be to the Radioactive Materials Unit, Minnesota
102.18 Department of Health, 625 Robert Street N, P.O. Box 64975, St. Paul, MN 55164-0975, or
102.19 e-mail at health.ram@state.mn.us.

102.20 [For text of items B and C, see M.R.]

102.21 [For text of subps 3 and 4, see M.R.]

102.22 **Subp. 5. Cancellation notice.** Each licensee who cancels a shipment for which advance
102.23 notification has been sent must send a cancellation notice to the commissioner and to the
102.24 governor of each state or to the governor's designee previously notified ~~and to the NRC's~~
102.25 ~~Director, Division of Security Policy, Office of Nuclear Security and Incident Response.~~

103.1 The licensee must send the cancellation notice before the shipment would have commenced
103.2 or as soon thereafter as possible. The licensee must state in the notice that it is a cancellation
103.3 and identify the advance notification that is being canceled.

103.4 [For text of subp 6, see M.R.]

103.5 Subp. 7. **Protection of information.** State officials, state employees, and other
103.6 individuals, whether or not licensees of the commissioner, the NRC, or an agreement state,
103.7 who receive schedule information of the kind specified in subpart 3 must protect that
103.8 information against unauthorized disclosure as specified in part 4731.8055, subpart 4.

103.9 **REPEALER.** Minnesota Rules, parts 4731.0407; 4731.0421; 4731.0455; and 4731.2600,
103.10 subpart 3, are repealed.