

# Office of the Revisor of Statutes

## Administrative Rules



**TITLE:** Adopted Permanent Rules Governing Radiation Safety

**AGENCY:** Department of Health

**REVISOR ID:** R-4477

**MINNESOTA RULES:** Chapters 4717 and 4731

**INCORPORATION BY REFERENCE:** American National Standard N432, Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography, American National Standards Institute (ANSI) (1981). Available through MnLink system. May be purchased from American National Standards Institute, Inc., 25 West 43rd Street, New York, NY 10036.

The attached rules are approved for  
filing with the Secretary of State

A handwritten signature in black ink that reads "Sandy Glass-Sirany".

Sandy Glass-Sirany  
Senior Assistant Revisor

200580

1.1 **Department of Health**1.2 **Adopted 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;

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 4731.0424.

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

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

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

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

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

2.21 A. uranium and thorium ores, concentrates of uranium and thorium ores, and other  
2.22 ores containing naturally occurring radioactive radionuclides that are intended to be processed  
2.23 for the use of these radionuclides;

2.24 B. natural uranium, depleted uranium, natural thorium, or their compounds or  
2.25 mixtures, provided they are unirradiated and in solid or liquid form;

3.1 C: radioactive material other than fissile material, for which the  $A_2$  value is  
3.2 unlimited; or

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

3.4 Subp. 131. **Low specific activity material group II.** "Low specific activity material  
3.5 group II" means:

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

3.7 B. other radioactive material in which the activity is distributed throughout and  
3.8 the estimated average specific activity does not exceed  $10^{-4} A_2/g$  for solids and gases or  
3.9  $10^{-5} A_2/g$  for liquids.

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

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

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

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

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

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

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

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

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

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

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

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

#### **4731.0200 GENERAL APPLICATIONS.**

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

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

#### **4731.0355 RECIPROCITY.**

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

#### **Subp. 3. Notification.**

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

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

5.2 (1) notify the commissioner in advance of any changes in the work location,  
5.3 schedule, radioactive material, or work activities;

5.4 *[For text of subitems (2) and (3), see M.R.]*

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

5.6 *[For text of subp 4, see M.R.]*

5.7 **4731.0400 SCOPE; ENFORCEMENT NOTICE.**

5.8 Subpart 1. **Scope.** Parts 4731.0400 to 4731.0424 establish requirements for the  
5.9 packaging, preparation for shipment, and transportation of licensed material.

5.10 Subp. 2. **Application of other law.** The packaging and transport of licensed material  
5.11 are subject to this chapter and the regulations of other agencies, such as the NRC, DOT,  
5.12 and United States Postal Service, having jurisdiction over means of transport. The  
5.13 requirements of parts 4731.0400 to 4731.0424 are in addition to, and not in substitution for,  
5.14 other requirements.

5.15 Subp. 3. **Applicability.** Parts 4731.0400 to 4731.0424 apply to any licensee authorized  
5.16 by a specific or general license issued by the commissioner to receive, possess, use, or  
5.17 transfer licensed material, if the licensee delivers that material to a carrier for transport,  
5.18 transports the material outside the site of usage as specified in an NRC or agreement state  
5.19 license, or transports that material on public highways. Parts 4731.0400 to 4731.0424 do  
5.20 not authorize possession of licensed material.

5.21 Subp. 4. **Definitions.** The following definitions apply to parts 4731.0400 to 4731.0424.

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

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

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

**4731.0401 REQUIREMENT FOR LICENSE.**

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

**4731.0403 SPECIFIC EXEMPTIONS.**

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

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

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

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

B. materials for which the activity concentration is not greater than the activity concentration values specified in part 4731.0422, subpart 3, or for which the consignment

7.1 activity is not greater than the limit for an exempt consignment under part 4731.0422, subpart  
7.2 3; and

7.3 C. Nonradioactive solid objects with radioactive substances present on any surfaces  
7.4 in quantities that do not exceed the levels cited in the definition of contamination in part  
7.5 4731.0400, subpart 4, item A.

7.6 Subp. 3. **Exemption from classification as fissile material.** Fissile material meeting  
7.7 at least one of the requirements in items A to F is exempt from classification as fissile  
7.8 material and from the fissile material package standards of Code of Federal Regulations,  
7.9 title 10, sections 71.55 and 71.59, but is subject to all other requirements of this chapter,  
7.10 except as noted:

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

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

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

7.19 **4731.0406 GENERAL LICENSE; NRC-APPROVED PACKAGE.**

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

7.21 Subp. 2. **Approved quality assurance program.** The general license issued under  
7.22 subpart 1 applies only to a licensee who has a quality assurance program approved by the  
7.23 commissioner as complying with part 4731.0420.

8.1 Subp. 3. **Compliance with conditions.** Each licensee issued a general license under  
8.2 subpart 1 must:

8.3 A. maintain a copy of the certificate of compliance or other approval of the package  
8.4 and has the drawings and other documents referenced in the approval relating to the use  
8.5 and maintenance of the packaging and to the actions to be taken before shipment;

8.6 B. comply with the terms and conditions of the license, certificate, or other  
8.7 approval, as applicable, and the applicable requirements of this chapter and Code of Federal  
8.8 Regulations, title 10, part 71, subpart H; and

8.9 C. submit in writing to the NRC, before the licensee's first use of the package, the  
8.10 licensee's name and license number and the package identification number specified in the  
8.11 package approval. For the submittal to the NRC, the licensee must use an approved method  
8.12 listed in the Code of Federal Regulations, title 10, section 71.1(a), addressed to: ATTN:  
8.13 Document Control Desk, Director, Division of Spent Fuel Storage and Transportation,  
8.14 Office of Nuclear Material Safety and Safeguards.

8.15 Subp. 4. **Package approval.** The general license issued under subpart 1 applies only  
8.16 when the package approval authorizes use of the package under the general license under  
8.17 subpart 1.

8.18 Subp. 5. **Type B or fissile material package.** For a Type B or fissile material package,  
8.19 the design of which was approved by the NRC before April 1, 1996, the general license  
8.20 under subpart 1 is subject to the additional restrictions of Code of Federal Regulations, title  
8.21 10, section 71.19.

8.22 **4731.0409 GENERAL LICENSE; FOREIGN-APPROVED PACKAGE.**

8.23 Subpart 1. **License for foreign-approved package.** A general license is issued to any  
8.24 licensee of the commissioner to transport, or to deliver to a carrier for transport, licensed  
8.25 material in a package the design of which has been approved in a foreign national competent

9.1 authority certificate that has been revalidated by the DOT as meeting the applicable  
9.2 requirements of Code of Federal Regulations, title 49, section 171.23.

9.3 Subp. 2. **Approved quality assurance program.** Except as otherwise provided in  
9.4 parts 4731.0400 to 4731.0424, the general license issued under subpart 1 applies only to a  
9.5 licensee who has a quality assurance program approved by the commissioner as complying  
9.6 with part 4731.0420.

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

9.9 Subp. 4. **Certificate conditions.** Each licensee issued a general license under subpart  
9.10 1 must:

9.11 A. maintain a copy of the applicable certificate, the revalidation, and the drawings  
9.12 and other documents referenced in the certificate, relating to the use and maintenance of  
9.13 the packaging and to the actions to be taken before shipment; and

9.14 B. comply with the terms and conditions of the certificate and revalidation and  
9.15 with the applicable requirements of this chapter and Code of Federal Regulations, title 10,  
9.16 part 71, subpart H.

9.17 **4731.0414 PRELIMINARY DETERMINATIONS.**

9.18 Before the first use of any packaging for the shipment of licensed material the licensee  
9.19 must ascertain that the determinations in Code of Federal Regulations, title 10, section  
9.20 71.85, have been made.

9.21 **4731.0415 ROUTINE DETERMINATIONS.**

9.22 Before each shipment of licensed material, a licensee must ensure that the package  
9.23 with its contents satisfies the applicable requirements of the license and parts 4731.0400 to  
9.24 4731.0424. The licensee must determine that:

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

**4731.0416 AIR TRANSPORT OF PLUTONIUM.**

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

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

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

**4731.0418 RECORDS AND REPORTS.**

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

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

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

C. volume and identification of coolant;

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

E. for each item of irradiated fissile material:

(1) identification by model number and serial number;

(2) irradiation and decay history to the extent appropriate to demonstrate that its nuclear and thermal characteristics comply with license conditions; and

- 11.1 (3) any abnormal or unusual condition relevant to radiation safety;
- 11.2 F. date of the shipment;
- 11.3 G. for fissile packages and for Type B packages, any special controls exercised;
- 11.4 H. name and address of the transferee;
- 11.5 I. address to which the shipment was made; and
- 11.6 J. results of the determinations required by part 4731.0415 and by the conditions
- 11.7 of the package approval.

11.8 Subp. 2. **Record availability.** The licensee must make available to the commissioner

11.9 for inspection, upon reasonable notice, all records required by parts 4731.0400 to 4731.0424.

11.10 Records are only valid if stamped, initialed, or signed and dated by authorized personnel,

11.11 or otherwise authenticated.

11.12 Subp. 3. **Record of package quality.** The licensee must maintain sufficient written

11.13 records to furnish evidence of the quality of packaging. The records to be maintained include

11.14 results of the determinations required by Code of Federal Regulations, title 10, part 71.85;

11.15 design, fabrication, and assembly records; results of reviews, inspections, tests, and audits;

11.16 results of monitoring work performance and materials analyses; and results of maintenance,

11.17 modification, and repair activities. Inspection, test, and audit records must identify the

11.18 inspector or data recorder, the type of observation, the results, the acceptability, and the

11.19 action taken in connection with any deficiencies noted. These records must be retained for

11.20 three years after the life of the packaging to which they apply.

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

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

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

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

12.6 **4731.0419 ADVANCE NOTIFICATION OF SHIPMENT OF IRRADIATED**  
12.7 **REACTOR FUEL AND NUCLEAR WASTE.**

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

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

12.11 B. the Tribal official of participating Tribes referenced in subpart 3, item B, or  
12.12 the official's designee, of the shipment of licensed material, within or across the boundary  
12.13 of the Tribe's reservation, before the transport, or delivery to a carrier, for transport, of  
12.14 licensed material outside the confines of the licensee's plant or other place of use or storage.

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

12.18 A. the licensed material is required by parts 4731.0400 to 4731.0424 to be in Type  
12.19 B packaging for transportation;

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

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

12.22 A. The notification required under this part must:

12.23 (1) be made in writing to the commissioner, the office of each appropriate  
12.24 state governor or governor's designee, the office of each appropriate Tribal official or Tribal

13.1 official's designee, and to the director of the Division of Security Policy, Office of Nuclear  
13.2 Security and Incident Response, NRC;

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

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

13.8 B. Contact information, including telephone and mailing addresses of the  
13.9 governors' designees and Tribal officials' designees of participating Tribes is available on  
13.10 the NRC Web site at: <https://scp.nrc.gov/special/designee.pdf>. The information is also  
13.11 available on request from the Director, Division of Material Safety, State, Tribal, and  
13.12 Rulemaking Programs, Office of Nuclear Material Safety and Safeguards, United States  
13.13 Nuclear Regulatory Commission, Washington, DC 20555-0001.

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

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

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

13.19 D. the seven-day period during which arrival of the shipment at state boundaries  
13.20 or Tribal reservation boundaries is estimated to occur;

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

13.22 Subp. 5. **Revision notice.** A licensee who finds that schedule information, previously  
13.23 furnished under this part to the commissioner and a governor or governor's designee or a  
13.24 Tribal official or Tribal official's designee, will not be met must telephone a responsible

14.1 individual in the commissioner's office and the governor or governor's designee or the Tribal  
14.2 official or the Tribal official's designee and inform the individual of the extent of the delay  
14.3 beyond the schedule originally reported.

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

14.5 **Subp. 6. Cancellation notice.**

14.6 A. A licensee who cancels an irradiated reactor fuel or nuclear waste shipment  
14.7 for which advance notification has been sent must send a cancellation notice to the  
14.8 commissioner, the governor of each state or the governor's designee previously notified,  
14.9 each Tribal official or the Tribal official's designee previously notified, and the director of  
14.10 the Division of Security Policy, Office of Nuclear Security and Incident Response, NRC.

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

14.12 **4731.0420 QUALITY ASSURANCE REQUIREMENTS.**

14.13 **Subpart 1. Program requirement.**

14.14 A. A licensee who uses a general license under part 4731.0406, 4731.0409,  
14.15 4731.0410, or 4731.0411, must establish, maintain, and execute a quality assurance program  
14.16 satisfying each of the applicable criteria of this part.

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

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

14.22 D. A program for transport container inspection and maintenance limited to  
14.23 radiographic exposure devices, source changers, or packages transporting these devices and  
14.24 meeting the requirements of part 4731.4090, subpart 2, items A to C, or an equivalent

15.1 requirement of the NRC or an agreement state, is deemed to satisfy the requirements of  
15.2 subpart 1 and part 4731.0406, subpart 2.

15.3 **Subp. 2. Quality assurance organization.**

15.4 A. A licensee is responsible for the establishment and execution of the quality  
15.5 assurance program. The licensee may delegate to others, such as contractors, agents, or  
15.6 consultants, the work of establishing and executing the quality assurance program, or any  
15.7 part of the quality assurance program, but must retain responsibility for the program. These  
15.8 activities include performing the functions associated with attaining quality objectives and  
15.9 the quality assurance functions.

15.10 B. The quality assurance functions are:

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

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

15.15 **Subp. 3. Quality assurance program.**

15.16 A. The licensee must document the quality assurance program by written  
15.17 procedures or instructions and carry out the program according to those procedures  
15.18 throughout the period during which the packaging is used. The licensee must identify the  
15.19 material and components to be covered by the quality assurance program, the major  
15.20 organizations participating in the program, and the designated functions of these  
15.21 organizations.

15.22 B. The licensee, through its quality assurance program, must provide control over  
15.23 activities affecting the quality of the identified materials and components to an extent  
15.24 consistent with their importance to safety, and as necessary to ensure conformance to the  
15.25 approved design of each individual package used for the shipment of radioactive material.

16.1 The licensee must ensure that activities affecting quality are accomplished under suitably  
16.2 controlled conditions. Controlled conditions include the use of appropriate equipment;  
16.3 suitable environmental conditions for accomplishing the activity, such as adequate  
16.4 cleanliness; and assurance that all prerequisites for the given activity have been satisfied.  
16.5 The licensee must take into account the need for special controls, processes, test equipment,  
16.6 tools, and skills to attain the required quality and the need for verification of quality by  
16.7 inspection and test.

16.8 C. The licensee must base the requirements and procedures of its quality assurance  
16.9 program on the following considerations concerning the complexity and proposed use of  
16.10 the package and its components:

- 16.11 (1) the impact of malfunction or failure of the item to safety;
- 16.12 (2) the design and fabrication complexity or uniqueness of the item;
- 16.13 (3) the need for special controls and surveillance over processes and  
16.14 equipment;
- 16.15 (4) the degree to which functional compliance can be demonstrated by  
16.16 inspection or test; and
- 16.17 (5) the quality history and degree of standardization of the item.

16.18 D. The licensee must provide for the indoctrination and training of personnel who  
16.19 perform activities that affect quality, as necessary to ensure that suitable proficiency is  
16.20 achieved and maintained. The licensee must review the status and adequacy of the quality  
16.21 assurance program at established intervals. Management of other organizations participating  
16.22 in the quality assurance program shall review regularly the status and adequacy of that part  
16.23 of the quality assurance program that a participating organization is executing.

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

17.2           A. A quality assurance program approval holder must submit a description of a  
17.3 proposed change to its commissioner-approved quality assurance program that will reduce  
17.4 commitments in the program description as approved by the commissioner. The quality  
17.5 assurance program approval holder shall not implement the change before receiving  
17.6 commissioner approval. The description of a proposed change to the commissioner approved  
17.7 quality assurance program must identify the change, the reason for the change, and the basis  
17.8 for concluding that the revised program incorporating the change continues to satisfy the  
17.9 applicable requirements of this part.

17.10          B. Each quality assurance program approval holder may change a previously  
17.11 approved quality assurance program without prior approval from the commissioner, if the  
17.12 change does not reduce the commitments in the quality assurance program previously  
17.13 approved by the commissioner. Changes to the quality assurance program that do not reduce  
17.14 the commitments must be submitted to the commissioner every 24 months. In addition to  
17.15 quality assurance program changes involving administrative improvements and clarifications,  
17.16 spelling corrections, and nonsubstantive changes to punctuation or editorial items, the  
17.17 following changes are not considered reductions in commitment:

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

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

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

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

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

18.11 C. Each quality assurance program approval holder must maintain records of  
18.12 quality assurance program changes.

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

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

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

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

19.4 Subp. 7. **Nonconforming materials, parts, or components.** The licensee must  
19.5 establish measures to control materials, parts, or components that do not conform to the  
19.6 licensee's requirements to prevent inadvertent use or installation. These measures must  
19.7 include, as appropriate, procedures for identification, documentation, segregation, disposition,  
19.8 and notification to affected organizations. Nonconforming items must be reviewed and  
19.9 accepted, rejected, repaired, or reworked according to documented procedures.

19.10 Subp. 8. **Corrective action.** The licensee must establish measures to ensure that  
19.11 conditions adverse to quality, such as deficiencies, deviations, defective material and  
19.12 equipment, and nonconformances, are promptly identified and corrected. In the case of a  
19.13 significant condition that is adverse to quality, the measures must ensure that the cause of  
19.14 the condition is determined and corrective action is taken to preclude repetition. The  
19.15 identification of the significant condition that is adverse to quality, the cause of the condition,  
19.16 and the corrective action taken must be documented and reported to appropriate levels of  
19.17 management.

19.18 Subp. 9. **Quality assurance records.** The licensee must maintain sufficient written  
19.19 records to describe the activities affecting quality. These records must include changes to  
19.20 the quality assurance program as required by subpart 4, and closely related specifications,  
19.21 such as required qualifications of personnel, procedures, and equipment. The records must  
19.22 include the instructions or procedures that establish a records retention program that is  
19.23 consistent with applicable regulations and that designates factors such as duration, location,  
19.24 and assigned responsibility for the records. The licensee must retain these records for three  
19.25 years beyond the date when the licensee last engages in the activity for which the quality  
19.26 assurance program was developed. If any portion of the quality assurance program, written

20.1 procedures, or instructions is superseded, the licensee must retain the superseded material  
 20.2 for three years.

20.3 Subp. 10. **Audits.** The licensee must carry out a comprehensive system of planned  
 20.4 and periodic audits to verify compliance with all aspects of the quality assurance program  
 20.5 and determine the effectiveness of the program. The audits must be performed according  
 20.6 to written procedures or checklists by appropriately trained personnel who do not have  
 20.7 direct responsibilities in the areas being audited. Audited results must be documented and  
 20.8 reviewed by management having responsibility in the area audited. Follow-up action,  
 20.9 including reaudit of deficient areas, must be taken where indicated.

20.10 **4731.0422 A<sub>1</sub> AND A<sub>2</sub> VALUES FOR RADIONUCLIDES.**

20.11 Subpart 1. [Repealed, 32 SR 831]

20.12 Subp. 1a. **A<sub>1</sub> and A<sub>2</sub> values.**

| 20.13 | Element and atomic   |                        |                                  |                        |                                  |
|-------|----------------------|------------------------|----------------------------------|------------------------|----------------------------------|
| 20.14 | number and symbol    |                        |                                  |                        |                                  |
| 20.15 | of radionuclide      |                        |                                  |                        |                                  |
| 20.16 |                      | A <sub>1</sub> (TBq)   | A <sub>1</sub> (Ci) <sup>b</sup> | A <sub>2</sub> (TBq)   | A <sub>2</sub> (Ci) <sup>b</sup> |
| 20.17 | Actinium (89)        |                        |                                  |                        |                                  |
| 20.18 | Ac-225 <sup>a</sup>  | 8.0 x 10 <sup>-1</sup> | 2.2 x 10 <sup>1</sup>            | 6.0 x 10 <sup>-3</sup> | 1.6 x 10 <sup>-1</sup>           |
| 20.19 | Ac-227 <sup>a</sup>  | 9.0 x 10 <sup>-1</sup> | 2.4 x 10 <sup>1</sup>            | 9.0 x 10 <sup>-5</sup> | 2.4 x 10 <sup>-3</sup>           |
| 20.20 | Ac-228               | 6.0 x 10 <sup>-1</sup> | 1.6 x 10 <sup>1</sup>            | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup>            |
| 20.21 | Silver (47)          |                        |                                  |                        |                                  |
| 20.22 | Ag-105               | 2.0                    | 5.4 x 10 <sup>1</sup>            | 2.0                    | 5.4 x 10 <sup>1</sup>            |
| 20.23 | Ag-108m <sup>a</sup> | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup>            | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup>            |
| 20.24 | Ag-110m <sup>a</sup> | 4.0 x 10 <sup>-1</sup> | 1.1 x 10 <sup>1</sup>            | 4.0 x 10 <sup>-1</sup> | 1.1 x 10 <sup>1</sup>            |
| 20.25 | Ag-111               | 2.0                    | 5.4 x 10 <sup>1</sup>            | 6.0 x 10 <sup>-1</sup> | 1.6 x 10 <sup>1</sup>            |
| 20.26 | Aluminum (13)        |                        |                                  |                        |                                  |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 21.1  | Al-26                | $1.0 \times 10^{-1}$ | 2.7               | $1.0 \times 10^{-1}$ | 2.7                  |
| 21.2  | Americium (95)       |                      |                   |                      |                      |
| 21.3  | Am-241               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 21.4  | Am-242m <sup>a</sup> | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 21.5  | Am-243 <sup>a</sup>  | 5.0                  | $1.4 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 21.6  | Argon (18)           |                      |                   |                      |                      |
| 21.7  | Ar-37                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 21.8  | Ar-39                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 21.9  | Ar-41                | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 21.10 | Arsenic (33)         |                      |                   |                      |                      |
| 21.11 | As-72                | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 21.12 | As-73                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 21.13 | As-74                | 1.0                  | $2.7 \times 10^1$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    |
| 21.14 | As-76                | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 21.15 | As-77                | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 21.16 | Astatine (85)        |                      |                   |                      |                      |
| 21.17 | At-211 <sup>a</sup>  | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 21.18 | Gold (79)            |                      |                   |                      |                      |
| 21.19 | Au-193               | 7.0                  | $1.9 \times 10^2$ | 2.0                  | $5.4 \times 10^1$    |
| 21.20 | Au-194               | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 21.21 | Au-195               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | 6.0                  | $1.6 \times 10^2$    |
| 21.22 | Au-198               | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 21.23 | Au-199               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 21.24 | Barium (56)          |                      |                   |                      |                      |
| 21.25 | Ba-131 <sup>a</sup>  | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 21.26 | Ba-133               | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$    |
| 21.27 | Ba-133m              | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 22.1  | Ba-140 <sup>a</sup>  | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $3.0 \times 10^{-1}$ | 8.1                  |
| 22.2  | Beryllium (4)        |                      |                   |                      |                      |
| 22.3  | Be-7                 | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 22.4  | Be-10                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 22.5  | Bismuth (83)         |                      |                   |                      |                      |
| 22.6  | Bi-205               | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 22.7  | Bi-206               | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 22.8  | Bi-207               | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 22.9  | Bi-210               | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 22.10 | Bi-210m <sup>a</sup> | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 22.11 | Bi-212 <sup>a</sup>  | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 22.12 | Berkelium (97)       |                      |                   |                      |                      |
| 22.13 | Bk-247               | 8.0                  | $2.2 \times 10^2$ | $8.0 \times 10^{-4}$ | $2.2 \times 10^{-2}$ |
| 22.14 | Bk-249 <sup>a</sup>  | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $3.0 \times 10^{-1}$ | 8.1                  |
| 22.15 | Bromine (35)         |                      |                   |                      |                      |
| 22.16 | Br-76                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 22.17 | Br-77                | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$    |
| 22.18 | Br-82                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 22.19 | Carbon (6)           |                      |                   |                      |                      |
| 22.20 | C-11                 | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 22.21 | C-14                 | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 3.0                  | $8.1 \times 10^1$    |
| 22.22 | Calcium (20)         |                      |                   |                      |                      |
| 22.23 | Ca-41                | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 22.24 | Ca-45                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 1.0                  | $2.7 \times 10^1$    |
| 22.25 | Ca-47 <sup>a</sup>   | 3.0                  | $8.1 \times 10^1$ | $3.0 \times 10^{-1}$ | 8.1                  |
| 22.26 | Cadmium (48)         |                      |                   |                      |                      |

|       |                     |                      |                      |                      |                      |
|-------|---------------------|----------------------|----------------------|----------------------|----------------------|
| 23.1  | Cd-109              | $3.0 \times 10^1$    | $8.1 \times 10^2$    | 2.0                  | $5.4 \times 10^1$    |
| 23.2  | Cd-113m             | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 23.3  | Cd-115 <sup>a</sup> | 3.0                  | $8.1 \times 10^1$    | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 23.4  | Cd-115m             | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 23.5  | Cerium (58)         |                      |                      |                      |                      |
| 23.6  | Ce-139              | 7.0                  | $1.9 \times 10^2$    | 2.0                  | $5.4 \times 10^1$    |
| 23.7  | Ce-141              | $2.0 \times 10^1$    | $5.4 \times 10^2$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 23.8  | Ce-143              | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 23.9  | Ce-144 <sup>a</sup> | $2.0 \times 10^{-1}$ | 5.4                  | $2.0 \times 10^{-1}$ | 5.4                  |
| 23.10 | Californium (98)    |                      |                      |                      |                      |
| 23.11 | Cf-248              | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $6.0 \times 10^{-3}$ | $1.6 \times 10^{-1}$ |
| 23.12 | Cf-249              | 3.0                  | $8.1 \times 10^1$    | $8.0 \times 10^{-4}$ | $2.2 \times 10^{-2}$ |
| 23.13 | Cf-250              | $2.0 \times 10^1$    | $5.4 \times 10^2$    | $2.0 \times 10^{-3}$ | $5.4 \times 10^{-2}$ |
| 23.14 | Cf-251              | 7.0                  | $1.9 \times 10^2$    | $7.0 \times 10^{-4}$ | $1.9 \times 10^{-2}$ |
| 23.15 | Cf-252              | $1.0 \times 10^{-1}$ | 2.7                  | $3.0 \times 10^{-3}$ | $8.1 \times 10^{-2}$ |
| 23.16 | Cf-253 <sup>a</sup> | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $4.0 \times 10^{-2}$ | 1.1                  |
| 23.17 | Cf-254              | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 23.18 | Chlorine (17)       |                      |                      |                      |                      |
| 23.19 | Cl-36               | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 23.20 | Cl-38               | $2.0 \times 10^{-1}$ | 5.4                  | $2.0 \times 10^{-1}$ | 5.4                  |
| 23.21 | Curium (96)         |                      |                      |                      |                      |
| 23.22 | Cm-240              | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 23.23 | Cm-241              | 2.0                  | $5.4 \times 10^1$    | 1.0                  | $2.7 \times 10^1$    |
| 23.24 | Cm-242              | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $1.0 \times 10^{-2}$ | $2.7 \times 10^{-1}$ |
| 23.25 | Cm-243              | 9.0                  | $2.4 \times 10^2$    | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 23.26 | Cm-244              | $2.0 \times 10^1$    | $5.4 \times 10^2$    | $2.0 \times 10^{-3}$ | $5.4 \times 10^{-2}$ |
| 23.27 | Cm-245              | 9.0                  | $2.4 \times 10^2$    | $9.0 \times 10^{-4}$ | $2.4 \times 10^{-2}$ |

|       |                     |                      |                      |                      |                      |
|-------|---------------------|----------------------|----------------------|----------------------|----------------------|
| 24.1  | Cm-246              | 9.0                  | $2.4 \times 10^2$    | $9.0 \times 10^{-4}$ | $2.4 \times 10^{-2}$ |
| 24.2  | Cm-247 <sup>a</sup> | 3.0                  | $8.1 \times 10^1$    | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 24.3  | Cm-248              | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ | $3.0 \times 10^{-4}$ | $8.1 \times 10^{-3}$ |
| 24.4  | Cobalt (27)         |                      |                      |                      |                      |
| 24.5  | Co-55               | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 24.6  | Co-56               | $3.0 \times 10^{-1}$ | 8.1                  | $3.0 \times 10^{-1}$ | 8.1                  |
| 24.7  | Co-57               | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $1.0 \times 10^1$    | $2.7 \times 10^2$    |
| 24.8  | Co-58               | 1.0                  | $2.7 \times 10^1$    | 1.0                  | $2.7 \times 10^1$    |
| 24.9  | Co-58m              | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 24.10 | Co-60               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 24.11 | Chromium (24)       |                      |                      |                      |                      |
| 24.12 | Cr-51               | $3.0 \times 10^1$    | $8.1 \times 10^2$    | $3.0 \times 10^1$    | $8.1 \times 10^2$    |
| 24.13 | Cesium (55)         |                      |                      |                      |                      |
| 24.14 | Cs-129              | 4.0                  | $1.1 \times 10^2$    | 4.0                  | $1.1 \times 10^2$    |
| 24.15 | Cs-131              | $3.0 \times 10^1$    | $8.1 \times 10^2$    | $3.0 \times 10^1$    | $8.1 \times 10^2$    |
| 24.16 | Cs-132              | 1.0                  | $2.7 \times 10^1$    | 1.0                  | $2.7 \times 10^1$    |
| 24.17 | Cs-134              | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 24.18 | Cs-134m             | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 24.19 | Cs-135              | $4.0 \times 10^1$    | $1.1 \times 10^3$    | 1.0                  | $2.7 \times 10^1$    |
| 24.20 | Cs-136              | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 24.21 | Cs-137 <sup>a</sup> | 2.0                  | $5.4 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 24.22 | Copper (29)         |                      |                      |                      |                      |
| 24.23 | Cu-64               | 6.0                  | $1.6 \times 10^2$    | 1.0                  | $2.7 \times 10^1$    |
| 24.24 | Cu-67               | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 24.25 | Dysprosium (66)     |                      |                      |                      |                      |
| 24.26 | Dy-159              | $2.0 \times 10^1$    | $5.4 \times 10^2$    | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 24.27 | Dy-165              | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |

|    |                      |                        |                       |                        |                       |
|----|----------------------|------------------------|-----------------------|------------------------|-----------------------|
| 1  | Dy-166 <sup>a</sup>  | 9.0 x 10 <sup>-1</sup> | 2.4 x 10 <sup>1</sup> | 3.0 x 10 <sup>-1</sup> | 8.1                   |
| 2  | Erbium (68)          |                        |                       |                        |                       |
| 3  | Er-169               | 4.0 x 10 <sup>1</sup>  | 1.1 x 10 <sup>3</sup> | 1.0                    | 2.7 x 10 <sup>1</sup> |
| 4  | Er-171               | 8.0 x 10 <sup>-1</sup> | 2.2 x 10 <sup>1</sup> | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup> |
| 5  | Europium (63)        |                        |                       |                        |                       |
| 6  | Eu-147               | 2.0                    | 5.4 x 10 <sup>1</sup> | 2.0                    | 5.4 x 10 <sup>1</sup> |
| 7  | Eu-148               | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup> | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup> |
| 8  | Eu-149               | 2.0 x 10 <sup>1</sup>  | 5.4 x 10 <sup>2</sup> | 2.0 x 10 <sup>1</sup>  | 5.4 x 10 <sup>2</sup> |
| 9  | Eu-150 (short-lived) | 2.0                    | 5.4 x 10 <sup>1</sup> | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup> |
| 10 | Eu-150 (long-lived)  | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup> | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup> |
| 11 | Eu-152               | 1.0                    | 2.7 x 10 <sup>1</sup> | 1.0                    | 2.7 x 10 <sup>1</sup> |
| 12 | Eu-152m              | 8.0 x 10 <sup>-1</sup> | 2.2 x 10 <sup>1</sup> | 8.0 x 10 <sup>-1</sup> | 2.2 x 10 <sup>1</sup> |
| 13 | Eu-154               | 9.0 x 10 <sup>-1</sup> | 2.4 x 10 <sup>1</sup> | 6.0 x 10 <sup>-1</sup> | 1.6 x 10 <sup>1</sup> |
| 14 | Eu-155               | 2.0 x 10 <sup>1</sup>  | 5.4 x 10 <sup>2</sup> | 3.0                    | 8.1 x 10 <sup>1</sup> |
| 15 | Eu-156               | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup> | 7.0 x 10 <sup>-1</sup> | 1.9 x 10 <sup>1</sup> |
| 16 | Fluorine (9)         |                        |                       |                        |                       |
| 17 | F-18                 | 1.0                    | 2.7 x 10 <sup>1</sup> | 6.0 x 10 <sup>-1</sup> | 1.6 x 10 <sup>1</sup> |
| 18 | Iron (26)            |                        |                       |                        |                       |
| 19 | Fe-52 <sup>a</sup>   | 3.0 x 10 <sup>-1</sup> | 8.1                   | 3.0 x 10 <sup>-1</sup> | 8.1                   |
| 20 | Fe-55                | 4.0 x 10 <sup>1</sup>  | 1.1 x 10 <sup>3</sup> | 4.0 x 10 <sup>1</sup>  | 1.1 x 10 <sup>3</sup> |
| 21 | Fe-59                | 9.0 x 10 <sup>-1</sup> | 2.4 x 10 <sup>1</sup> | 9.0 x 10 <sup>-1</sup> | 2.4 x 10 <sup>1</sup> |
| 22 | Fe-60 <sup>a</sup>   | 4.0 x 10 <sup>1</sup>  | 1.1 x 10 <sup>3</sup> | 2.0 x 10 <sup>-1</sup> | 5.4                   |
| 23 | Gallium (31)         |                        |                       |                        |                       |
| 24 | Ga-67                | 7.0                    | 1.9 x 10 <sup>2</sup> | 3.0                    | 8.1 x 10 <sup>1</sup> |
| 25 | Ga-68                | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup> | 5.0 x 10 <sup>-1</sup> | 1.4 x 10 <sup>1</sup> |
| 26 | Ga-72                | 4.0 x 10 <sup>-1</sup> | 1.1 x 10 <sup>1</sup> | 4.0 x 10 <sup>-1</sup> | 1.1 x 10 <sup>1</sup> |
| 27 | Gadolinium (64)      |                        |                       |                        |                       |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 26.1  | Gd-146 <sup>a</sup>  | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 26.2  | Gd-148               | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $2.0 \times 10^{-3}$ | $5.4 \times 10^{-2}$ |
| 26.3  | Gd-153               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | 9.0                  | $2.4 \times 10^2$    |
| 26.4  | Gd-159               | 3.0                  | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 26.5  | Germanium (32)       |                      |                   |                      |                      |
| 26.6  | Ge-68 <sup>a</sup>   | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 26.7  | Ge-71                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 26.8  | Ge-77                | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 26.9  | Hafnium (72)         |                      |                   |                      |                      |
| 26.10 | Hf-172 <sup>a</sup>  | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 26.11 | Hf-175               | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$    |
| 26.12 | Hf-181               | 2.0                  | $5.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 26.13 | Hf-182               | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 26.14 | Mercury (80)         |                      |                   |                      |                      |
| 26.15 | Hg-194 <sup>a</sup>  | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 26.16 | Hg-195m <sup>a</sup> | 3.0                  | $8.1 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 26.17 | Hg-197               | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $1.0 \times 10^1$    | $2.7 \times 10^2$    |
| 26.18 | Hg-197m              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 26.19 | Hg-203               | 5.0                  | $1.4 \times 10^2$ | 1.0                  | $2.7 \times 10^1$    |
| 26.20 | Holmium (67)         |                      |                   |                      |                      |
| 26.21 | Ho-166               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 26.22 | Ho-166m              | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 26.23 | Iodine (53)          |                      |                   |                      |                      |
| 26.24 | I-123                | 6.0                  | $1.6 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 26.25 | I-124                | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 26.26 | I-125                | $2.0 \times 10^1$    | $5.4 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 26.27 | I-126                | 2.0                  | $5.4 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |

|       |                      |                      |                      |                      |                   |
|-------|----------------------|----------------------|----------------------|----------------------|-------------------|
| 27.1  | I-129                | Unlimited            | Unlimited            | Unlimited            | Unlimited         |
| 27.2  | I-131                | 3.0                  | $8.1 \times 10^1$    | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |
| 27.3  | I-132                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 27.4  | I-133                | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 27.5  | I-134                | $3.0 \times 10^{-1}$ | 8.1                  | $3.0 \times 10^{-1}$ | 8.1               |
| 27.6  | I-135 <sup>a</sup>   | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 27.7  | Indium (49)          |                      |                      |                      |                   |
| 27.8  | In-111               | 3.0                  | $8.1 \times 10^1$    | 3.0                  | $8.1 \times 10^1$ |
| 27.9  | In-113m              | 4.0                  | $1.1 \times 10^2$    | 2.0                  | $5.4 \times 10^1$ |
| 27.10 | In-114m <sup>a</sup> | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 27.11 | In-115m              | 7.0                  | $1.9 \times 10^2$    | 1.0                  | $2.7 \times 10^1$ |
| 27.12 | Iridium (77)         |                      |                      |                      |                   |
| 27.13 | Ir-189 <sup>a</sup>  | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $1.0 \times 10^1$    | $2.7 \times 10^2$ |
| 27.14 | Ir-190               | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |
| 27.15 | Ir-192               | 1.0 <sup>c</sup>     | $2.7 \times 10^{1c}$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 27.16 | Ir-194               | $3.0 \times 10^{-1}$ | 8.1                  | $3.0 \times 10^{-1}$ | 8.1               |
| 27.17 | Potassium (19)       |                      |                      |                      |                   |
| 27.18 | K-40                 | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ |
| 27.19 | K-42                 | $2.0 \times 10^{-1}$ | 5.4                  | $2.0 \times 10^{-1}$ | 5.4               |
| 27.20 | K-43                 | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 27.21 | Krypton (36)         |                      |                      |                      |                   |
| 27.22 | Kr-79                | 4.0                  | $1.1 \times 10^2$    | 2.0                  | $5.4 \times 10^1$ |
| 27.23 | Kr-81                | $4.0 \times 10^1$    | $1.1 \times 10^3$    | $4.0 \times 10^1$    | $1.1 \times 10^3$ |
| 27.24 | Kr-85                | $1.0 \times 10^1$    | $2.7 \times 10^2$    | $1.0 \times 10^1$    | $2.7 \times 10^2$ |
| 27.25 | Kr-85m               | 8.0                  | $2.2 \times 10^2$    | 3.0                  | $8.1 \times 10^1$ |
| 27.26 | Kr-87                | $2.0 \times 10^{-1}$ | 5.4                  | $2.0 \times 10^{-1}$ | 5.4               |
| 27.27 | Lanthanum (57)       |                      |                      |                      |                   |

|       |                       |                      |                   |                      |                   |
|-------|-----------------------|----------------------|-------------------|----------------------|-------------------|
| 28.1  | La-137                | $3.0 \times 10^1$    | $8.1 \times 10^2$ | 6.0                  | $1.6 \times 10^2$ |
| 28.2  | La-140                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 28.3  | Lutetium (71)         |                      |                   |                      |                   |
| 28.4  | Lu-172                | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 28.5  | Lu-173                | 8.0                  | $2.2 \times 10^2$ | 8.0                  | $2.2 \times 10^2$ |
| 28.6  | Lu-174                | 9.0                  | $2.4 \times 10^2$ | 9.0                  | $2.4 \times 10^2$ |
| 28.7  | Lu-174m               | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $1.0 \times 10^1$    | $2.7 \times 10^2$ |
| 28.8  | Lu-177                | $3.0 \times 10^1$    | $8.1 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |
| 28.9  | Magnesium (12)        |                      |                   |                      |                   |
| 28.10 | Mg-28 <sup>a</sup>    | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 28.11 | Manganese (25)        |                      |                   |                      |                   |
| 28.12 | Mn-52                 | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 28.13 | Mn-53                 | Unlimited            | Unlimited         | Unlimited            | Unlimited         |
| 28.14 | Mn-54                 | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$ |
| 28.15 | Mn-56                 | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 28.16 | Molybdenum (42)       |                      |                   |                      |                   |
| 28.17 | Mo-93                 | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^1$    | $5.4 \times 10^2$ |
| 28.18 | Mo-99 <sup>a, h</sup> | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 28.19 | Nitrogen (7)          |                      |                   |                      |                   |
| 28.20 | N-13                  | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 28.21 | Sodium (11)           |                      |                   |                      |                   |
| 28.22 | Na-22                 | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 28.23 | Na-24                 | $2.0 \times 10^{-1}$ | 5.4               | $2.0 \times 10^{-1}$ | 5.4               |
| 28.24 | Niobium (41)          |                      |                   |                      |                   |
| 28.25 | Nb-93m                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $3.0 \times 10^1$    | $8.1 \times 10^2$ |
| 28.26 | Nb-94                 | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 29.1  | Nb-95                | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 29.2  | Nb-97                | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 29.3  | Neodymium (60)       |                      |                   |                      |                      |
| 29.4  | Nd-147               | 6.0                  | $1.6 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 29.5  | Nd-149               | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 29.6  | Nickel (28)          |                      |                   |                      |                      |
| 29.7  | Ni-59                | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 29.8  | Ni-63                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $3.0 \times 10^1$    | $8.1 \times 10^2$    |
| 29.9  | Ni-65                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 29.10 | Neptunium (93)       |                      |                   |                      |                      |
| 29.11 | Np-235               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 29.12 | Np-236 (short-lived) | $2.0 \times 10^1$    | $5.4 \times 10^2$ | 2.0                  | $5.4 \times 10^1$    |
| 29.13 | Np-236 (long-lived)  | $9.0 \times 10^0$    | $2.4 \times 10^2$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 29.14 | Np-237               | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $2.0 \times 10^{-3}$ | $5.4 \times 10^{-2}$ |
| 29.15 | Np-239               | 7.0                  | $1.9 \times 10^2$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 29.16 | Osmium (76)          |                      |                   |                      |                      |
| 29.17 | Os-185               | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 29.18 | Os-191               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | 2.0                  | $5.4 \times 10^1$    |
| 29.19 | Os-191m              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $3.0 \times 10^1$    | $8.1 \times 10^2$    |
| 29.20 | Os-193               | 2.0                  | $5.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 29.21 | Os-194 <sup>a</sup>  | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 29.22 | Phosphorus (15)      |                      |                   |                      |                      |
| 29.23 | P-32                 | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 29.24 | P-33                 | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 1.0                  | $2.7 \times 10^1$    |
| 29.25 | Protactinium (91)    |                      |                   |                      |                      |
| 29.26 | Pa-230 <sup>a</sup>  | 2.0                  | $5.4 \times 10^1$ | $7.0 \times 10^{-2}$ | 1.9                  |
| 29.27 | Pa-231               | 4.0                  | $1.1 \times 10^2$ | $4.0 \times 10^{-4}$ | $1.1 \times 10^{-2}$ |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 30.1  | Pa-233               | 5.0                  | $1.4 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 30.2  | Lead (82)            |                      |                   |                      |                      |
| 30.3  | Pb-201               | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 30.4  | Pb-202               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 30.5  | Pb-203               | 4.0                  | $1.1 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 30.6  | Pb-205               | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 30.7  | Pb-210 <sup>a</sup>  | 1.0                  | $2.7 \times 10^1$ | $5.0 \times 10^{-2}$ | 1.4                  |
| 30.8  | Pb-212 <sup>a</sup>  | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $2.0 \times 10^{-1}$ | 5.4                  |
| 30.9  | Palladium (46)       |                      |                   |                      |                      |
| 30.10 | Pd-103 <sup>a</sup>  | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 30.11 | Pd-107               | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 30.12 | Pd-109               | 2.0                  | $5.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 30.13 | Promethium (61)      |                      |                   |                      |                      |
| 30.14 | Pm-143               | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$    |
| 30.15 | Pm-144               | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 30.16 | Pm-145               | $3.0 \times 10^1$    | $8.1 \times 10^2$ | $1.0 \times 10^1$    | $2.7 \times 10^2$    |
| 30.17 | Pm-147               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 2.0                  | $5.4 \times 10^1$    |
| 30.18 | Pm-148m <sup>a</sup> | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 30.19 | Pm-149               | 2.0                  | $5.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 30.20 | Pm-151               | 2.0                  | $5.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 30.21 | Polonium (84)        |                      |                   |                      |                      |
| 30.22 | Po-210               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 30.23 | Praseodymium (59)    |                      |                   |                      |                      |
| 30.24 | Pr-142               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 30.25 | Pr-143               | 3.0                  | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 30.26 | Platinum (78)        |                      |                   |                      |                      |
| 30.27 | Pt-188 <sup>a</sup>  | 1.0                  | $2.7 \times 10^1$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$    |

|       |                     |                      |                   |                      |                      |
|-------|---------------------|----------------------|-------------------|----------------------|----------------------|
| 31.1  | Pt-191              | 4.0                  | $1.1 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 31.2  | Pt-193              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 31.3  | Pt-193m             | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 31.4  | Pt-195m             | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 31.5  | Pt-197              | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 31.6  | Pt-197m             | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 31.7  | Plutonium (94)      |                      |                   |                      |                      |
| 31.8  | Pu-236              | $3.0 \times 10^1$    | $8.1 \times 10^2$ | $3.0 \times 10^{-3}$ | $8.1 \times 10^{-2}$ |
| 31.9  | Pu-237              | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 31.10 | Pu-238              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 31.11 | Pu-239              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 31.12 | Pu-240              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 31.13 | Pu-241 <sup>a</sup> | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $6.0 \times 10^{-2}$ | 1.6                  |
| 31.14 | Pu-242              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 31.15 | Pu-244 <sup>a</sup> | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 31.16 | Radium (88)         |                      |                   |                      |                      |
| 31.17 | Ra-223 <sup>a</sup> | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $7.0 \times 10^{-3}$ | $1.9 \times 10^{-1}$ |
| 31.18 | Ra-224 <sup>a</sup> | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 31.19 | Ra-225 <sup>a</sup> | $2.0 \times 10^{-1}$ | 5.4               | $4.0 \times 10^{-3}$ | $1.1 \times 10^{-1}$ |
| 31.20 | Ra-226 <sup>a</sup> | $2.0 \times 10^{-1}$ | 5.4               | $3.0 \times 10^{-3}$ | $8.1 \times 10^{-2}$ |
| 31.21 | Ra-228 <sup>a</sup> | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 31.22 | Rubidium (37)       |                      |                   |                      |                      |
| 31.23 | Rb-81               | 2.0                  | $5.4 \times 10^1$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$    |
| 31.24 | Rb-83 <sup>a</sup>  | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 31.25 | Rb-84               | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 31.26 | Rb-86               | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 31.27 | Rb-87               | Unlimited            | Unlimited         | Unlimited            | Unlimited            |

|       |                     |                      |                   |                      |                      |
|-------|---------------------|----------------------|-------------------|----------------------|----------------------|
| 32.1  | Rb (nat)            | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 32.2  | Rhenium (75)        |                      |                   |                      |                      |
| 32.3  | Re-184              | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 32.4  | Re-184m             | 3.0                  | $8.1 \times 10^1$ | 1.0                  | $2.7 \times 10^1$    |
| 32.5  | Re-186              | 2.0                  | $5.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 32.6  | Re-187              | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 32.7  | Re-188              | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 32.8  | Re-189 <sup>a</sup> | 3.0                  | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 32.9  | Re (nat)            | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 32.10 | Rhodium (45)        |                      |                   |                      |                      |
| 32.11 | Rh-99               | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 32.12 | Rh-101              | 4.0                  | $1.1 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 32.13 | Rh-102              | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 32.14 | Rh-102m             | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 32.15 | Rh-103m             | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 32.16 | Rh-105              | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$    |
| 32.17 | Radon (86)          |                      |                   |                      |                      |
| 32.18 | Rn-222 <sup>a</sup> | $3.0 \times 10^{-1}$ | 8.1               | $4.0 \times 10^{-3}$ | $1.1 \times 10^{-1}$ |
| 32.19 | Ruthenium (44)      |                      |                   |                      |                      |
| 32.20 | Ru-97               | 5.0                  | $1.4 \times 10^2$ | 5.0                  | $1.4 \times 10^2$    |
| 32.21 | Ru-103 <sup>a</sup> | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 32.22 | Ru-105              | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 32.23 | Ru-106 <sup>a</sup> | $2.0 \times 10^{-1}$ | 5.4               | $2.0 \times 10^{-1}$ | 5.4                  |
| 32.24 | Sulphur (16)        |                      |                   |                      |                      |
| 32.25 | S-35                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 3.0                  | $8.1 \times 10^1$    |
| 32.26 | Antimony (51)       |                      |                   |                      |                      |
| 32.27 | Sb-122              | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |

|       |                      |                      |                   |                      |                   |
|-------|----------------------|----------------------|-------------------|----------------------|-------------------|
| 33.1  | Sb-124               | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 33.2  | Sb-125               | 2.0                  | $5.4 \times 10^1$ | 1.0                  | $2.7 \times 10^1$ |
| 33.3  | Sb-126               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 33.4  | Scandium (21)        |                      |                   |                      |                   |
| 33.5  | Sc-44                | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 33.6  | Sc-46                | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 33.7  | Sc-47                | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |
| 33.8  | Sc-48                | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 33.9  | Selenium (34)        |                      |                   |                      |                   |
| 33.10 | Se-75                | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$ |
| 33.11 | Se-79                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 2.0                  | $5.4 \times 10^1$ |
| 33.12 | Silicon (14)         |                      |                   |                      |                   |
| 33.13 | Si-31                | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 33.14 | Si-32                | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 33.15 | Samarium (62)        |                      |                   |                      |                   |
| 33.16 | Sm-145               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^1$    | $2.7 \times 10^2$ |
| 33.17 | Sm-147               | Unlimited            | Unlimited         | Unlimited            | Unlimited         |
| 33.18 | Sm-151               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $1.0 \times 10^1$    | $2.7 \times 10^2$ |
| 33.19 | Sm-153               | 9.0                  | $2.4 \times 10^2$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 33.20 | Tin (50)             |                      |                   |                      |                   |
| 33.21 | Sn-113 <sup>a</sup>  | 4.0                  | $1.1 \times 10^2$ | 2.0                  | $5.4 \times 10^1$ |
| 33.22 | Sn-117m              | 7.0                  | $1.9 \times 10^2$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 33.23 | Sn-119m              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $3.0 \times 10^1$    | $8.1 \times 10^2$ |
| 33.24 | Sn-121m <sup>a</sup> | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ |
| 33.25 | Sn-123               | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 33.26 | Sn-125               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 33.27 | Sn-126 <sup>a</sup>  | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |

|       |                     |                      |                   |                      |                   |
|-------|---------------------|----------------------|-------------------|----------------------|-------------------|
| 34.1  | Strontium (38)      |                      |                   |                      |                   |
| 34.2  | Sr-82 <sup>a</sup>  | $2.0 \times 10^{-1}$ | 5.4               | $2.0 \times 10^{-1}$ | 5.4               |
| 34.3  | Sr-85               | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$ |
| 34.4  | Sr-85m              | 5.0                  | $1.4 \times 10^2$ | 5.0                  | $1.4 \times 10^2$ |
| 34.5  | Sr-87m              | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$ |
| 34.6  | Sr-89               | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 34.7  | Sr-90 <sup>a</sup>  | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 34.8  | Sr-91 <sup>a</sup>  | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 34.9  | Sr-92 <sup>a</sup>  | 1.0                  | $2.7 \times 10^1$ | $3.0 \times 10^{-1}$ | 8.1               |
| 34.10 | Tritium (1)         |                      |                   |                      |                   |
| 34.11 | T (H-3)             | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$ |
| 34.12 | Tantalum (73)       |                      |                   |                      |                   |
| 34.13 | Ta-178 (long-lived) | 1.0                  | $2.7 \times 10^1$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ |
| 34.14 | Ta-179              | $3.0 \times 10^1$    | $8.1 \times 10^2$ | $3.0 \times 10^1$    | $8.1 \times 10^2$ |
| 34.15 | Ta-182              | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ |
| 34.16 | Terbium (65)        |                      |                   |                      |                   |
| 34.17 | Tb-157              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$ |
| 34.18 | Tb-158              | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$ |
| 34.19 | Tb-160              | 1.0                  | $2.7 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 34.20 | Technetium (43)     |                      |                   |                      |                   |
| 34.21 | Tc-95m <sup>a</sup> | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$ |
| 34.22 | Tc-96               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 34.23 | Tc-96m <sup>a</sup> | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 34.24 | Tc-97               | Unlimited            | Unlimited         | Unlimited            | Unlimited         |
| 34.25 | Tc-97m              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | 1.0                  | $2.7 \times 10^1$ |
| 34.26 | Tc-98               | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ |
| 34.27 | Tc-99               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ |

|       |                      |                      |                   |                      |                      |
|-------|----------------------|----------------------|-------------------|----------------------|----------------------|
| 35.1  | Tc-99m               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | 4.0                  | $1.1 \times 10^2$    |
| 35.2  | Tellurium (52)       |                      |                   |                      |                      |
| 35.3  | Te-121               | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |
| 35.4  | Te-121m              | 5.0                  | $1.4 \times 10^2$ | 3.0                  | $8.1 \times 10^1$    |
| 35.5  | Te-123m              | 8.0                  | $2.2 \times 10^2$ | 1.0                  | $2.7 \times 10^1$    |
| 35.6  | Te-125m              | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    |
| 35.7  | Te-127               | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 35.8  | Te-127m <sup>a</sup> | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 35.9  | Te-129               | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 35.10 | Te-129m <sup>a</sup> | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 35.11 | Te-131m <sup>a</sup> | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$ | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$    |
| 35.12 | Te-132 <sup>a</sup>  | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 35.13 | Thorium (90)         |                      |                   |                      |                      |
| 35.14 | Th-227               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $5.0 \times 10^{-3}$ | $1.4 \times 10^{-1}$ |
| 35.15 | Th-228 <sup>a</sup>  | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 35.16 | Th-229               | 5.0                  | $1.4 \times 10^2$ | $5.0 \times 10^{-4}$ | $1.4 \times 10^{-2}$ |
| 35.17 | Th-230               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 35.18 | Th-231               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 35.19 | Th-232               | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 35.20 | Th-234 <sup>a</sup>  | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1                  |
| 35.21 | Th (nat)             | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 35.22 | Titanium (22)        |                      |                   |                      |                      |
| 35.23 | Ti-44 <sup>a</sup>   | $5.0 \times 10^{-1}$ | $1.4 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 35.24 | Thallium (81)        |                      |                   |                      |                      |
| 35.25 | Tl-200               | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$    |
| 35.26 | Tl-201               | $1.0 \times 10^1$    | $2.7 \times 10^2$ | 4.0                  | $1.1 \times 10^2$    |
| 35.27 | Tl-202               | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |

|       |                                 |                   |                   |                      |                      |
|-------|---------------------------------|-------------------|-------------------|----------------------|----------------------|
| 36.1  | Tl-204                          | $1.0 \times 10^1$ | $2.7 \times 10^2$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 36.2  | Thulium (69)                    |                   |                   |                      |                      |
| 36.3  | Tm-167                          | 7.0               | $1.9 \times 10^2$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$    |
| 36.4  | Tm-170                          | 3.0               | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 36.5  | Tm-171                          | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 36.6  | Uranium (92)                    |                   |                   |                      |                      |
| 36.7  | U-230 (fast lung                |                   |                   |                      |                      |
| 36.8  | absorption) <sup>a,d</sup>      | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $1.0 \times 10^{-1}$ | 2.7                  |
| 36.9  | U-230 (medium                   |                   |                   |                      |                      |
| 36.10 | lung absorption) <sup>a,e</sup> | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $4.0 \times 10^{-3}$ | $1.1 \times 10^{-1}$ |
| 36.11 | U-230 (slow lung                |                   |                   |                      |                      |
| 36.12 | absorption) <sup>a,f</sup>      | $3.0 \times 10^1$ | $8.1 \times 10^2$ | $3.0 \times 10^{-3}$ | $8.1 \times 10^{-2}$ |
| 36.13 | U-232 (fast lung                |                   |                   |                      |                      |
| 36.14 | absorption) <sup>d</sup>        | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $1.0 \times 10^{-2}$ | $2.7 \times 10^{-1}$ |
| 36.15 | U-232 (medium                   |                   |                   |                      |                      |
| 36.16 | lung absorption) <sup>e</sup>   | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $7.0 \times 10^{-3}$ | $1.9 \times 10^{-1}$ |
| 36.17 | U-232 (slow lung                |                   |                   |                      |                      |
| 36.18 | absorption) <sup>f</sup>        | $1.0 \times 10^1$ | $2.7 \times 10^2$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-2}$ |
| 36.19 | U-233 (fast lung                |                   |                   |                      |                      |
| 36.20 | absorption) <sup>d</sup>        | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $9.0 \times 10^{-2}$ | 2.4                  |
| 36.21 | U-233 (medium                   |                   |                   |                      |                      |
| 36.22 | lung absorption) <sup>e</sup>   | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 36.23 | U-233 (slow lung                |                   |                   |                      |                      |
| 36.24 | absorption) <sup>f</sup>        | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $6.0 \times 10^{-3}$ | $1.6 \times 10^{-1}$ |
| 36.25 | U-234 (fast lung                |                   |                   |                      |                      |
| 36.26 | absorption) <sup>d</sup>        | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $9.0 \times 10^{-2}$ | 2.4                  |
| 36.27 | U-234 (medium                   |                   |                   |                      |                      |
| 36.28 | lung absorption) <sup>e</sup>   | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 36.29 | U-234 (slow lung                |                   |                   |                      |                      |
| 36.30 | absorption) <sup>f</sup>        | $4.0 \times 10^1$ | $1.1 \times 10^3$ | $6.0 \times 10^{-3}$ | $1.6 \times 10^{-1}$ |
| 36.31 | U-235 (all lung                 |                   |                   |                      |                      |
| 36.32 | absorption                      |                   |                   |                      |                      |
| 36.33 | types) <sup>a,d,e,f</sup>       | Unlimited         | Unlimited         | Unlimited            | Unlimited            |

|       |                                    |                      |                   |                      |                      |
|-------|------------------------------------|----------------------|-------------------|----------------------|----------------------|
| 37.1  | U-236 (fast lung                   |                      |                   |                      |                      |
| 37.2  | absorption) <sup>d</sup>           | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 37.3  | U-236 (medium                      |                      |                   |                      |                      |
| 37.4  | lung absorption) <sup>e</sup>      | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $2.0 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |
| 37.5  | U-236 (slow lung                   |                      |                   |                      |                      |
| 37.6  | absorption) <sup>f</sup>           | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $6.0 \times 10^{-3}$ | $1.6 \times 10^{-1}$ |
| 37.7  | U-238 (all lung                    |                      |                   |                      |                      |
| 37.8  | absorption types) <sup>d,e,f</sup> | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 37.9  | U (nat)                            | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 37.10 | U (enriched to 20%                 |                      |                   |                      |                      |
| 37.11 | or less) <sup>g</sup>              | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
| 37.12 | U (dep)                            | Unlimited            | Unlimited         | Unlimited            | Unlimited            |
|       |                                    |                      |                   |                      |                      |
| 37.13 | Vanadium (23)                      |                      |                   |                      |                      |
| 37.14 | V-48                               | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 37.15 | V-49                               | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
|       |                                    |                      |                   |                      |                      |
| 37.16 | Tungsten (74)                      |                      |                   |                      |                      |
| 37.17 | W-178 <sup>a</sup>                 | 9.0                  | $2.4 \times 10^2$ | 5.0                  | $1.4 \times 10^2$    |
| 37.18 | W-181                              | $3.0 \times 10^1$    | $8.1 \times 10^2$ | $3.0 \times 10^1$    | $8.1 \times 10^2$    |
| 37.19 | W-185                              | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$    |
| 37.20 | W-187                              | 2.0                  | $5.4 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$    |
| 37.21 | W-188 <sup>a</sup>                 | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $3.0 \times 10^{-1}$ | 8.1                  |
|       |                                    |                      |                   |                      |                      |
| 37.22 | Xenon (54)                         |                      |                   |                      |                      |
| 37.23 | Xe-122 <sup>a</sup>                | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$    |
| 37.24 | Xe-123                             | 2.0                  | $5.4 \times 10^1$ | $7.0 \times 10^{-1}$ | $1.9 \times 10^1$    |
| 37.25 | Xe-127                             | 4.0                  | $1.1 \times 10^2$ | 2.0                  | $5.4 \times 10^1$    |
| 37.26 | Xe-131m                            | $4.0 \times 10^1$    | $1.1 \times 10^3$ | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 37.27 | Xe-133                             | $2.0 \times 10^1$    | $5.4 \times 10^2$ | $1.0 \times 10^1$    | $2.7 \times 10^2$    |
| 37.28 | Xe-135                             | 3.0                  | $8.1 \times 10^1$ | 2.0                  | $5.4 \times 10^1$    |

## 38.1 Yttrium (39)

|      |                   |                      |                   |                      |                   |
|------|-------------------|----------------------|-------------------|----------------------|-------------------|
| 38.2 | Y-87 <sup>a</sup> | 1.0                  | $2.7 \times 10^1$ | 1.0                  | $2.7 \times 10^1$ |
| 38.3 | Y-88              | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |
| 38.4 | Y-90              | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |
| 38.5 | Y-91              | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 38.6 | Y-91m             | 2.0                  | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$ |
| 38.7 | Y-92              | $2.0 \times 10^{-1}$ | 5.4               | $2.0 \times 10^{-1}$ | 5.4               |
| 38.8 | Y-93              | $3.0 \times 10^{-1}$ | 8.1               | $3.0 \times 10^{-1}$ | 8.1               |

## 38.9 Ytterbium (70)

|       |        |                   |                   |                      |                   |
|-------|--------|-------------------|-------------------|----------------------|-------------------|
| 38.10 | Yb-169 | 4.0               | $1.1 \times 10^2$ | 1.0                  | $2.7 \times 10^1$ |
| 38.11 | Yb-175 | $3.0 \times 10^1$ | $8.1 \times 10^2$ | $9.0 \times 10^{-1}$ | $2.4 \times 10^1$ |

## 38.12 Zinc (30)

|       |                     |     |                   |                      |                   |
|-------|---------------------|-----|-------------------|----------------------|-------------------|
| 38.13 | Zn-65               | 2.0 | $5.4 \times 10^1$ | 2.0                  | $5.4 \times 10^1$ |
| 38.14 | Zn-69               | 3.0 | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |
| 38.15 | Zn-69m <sup>a</sup> | 3.0 | $8.1 \times 10^1$ | $6.0 \times 10^{-1}$ | $1.6 \times 10^1$ |

## 38.16 Zirconium (40)

|       |                    |                      |                   |                      |                   |
|-------|--------------------|----------------------|-------------------|----------------------|-------------------|
| 38.17 | Zr-88              | 3.0                  | $8.1 \times 10^1$ | 3.0                  | $8.1 \times 10^1$ |
| 38.18 | Zr-93              | Unlimited            | Unlimited         | Unlimited            | Unlimited         |
| 38.19 | Zr-95 <sup>a</sup> | 2.0                  | $5.4 \times 10^1$ | $8.0 \times 10^{-1}$ | $2.2 \times 10^1$ |
| 38.20 | Zr-97 <sup>a</sup> | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ | $4.0 \times 10^{-1}$ | $1.1 \times 10^1$ |

38.21 <sup>a</sup>A<sub>1</sub> and A<sub>2</sub> values include contributions from daughter nuclides with half-lives less than  
 38.22 ten days as listed in the following:

|       |       |        |
|-------|-------|--------|
| 38.23 | Mg-28 | Al-28  |
| 38.24 | Ca-47 | Sc-47  |
| 38.25 | Ti-44 | Sc-44  |
| 38.26 | Fe-52 | Mn-52m |
| 38.27 | Fe-60 | Co-60m |

|       |         |               |
|-------|---------|---------------|
| 39.1  | Zn-69m  | Zn-69         |
| 39.2  | Ge-68   | Ga-68         |
| 39.3  | Rb-83   | Kr-83m        |
| 39.4  | Sr-82   | Rb-82         |
| 39.5  | Sr-90   | Y-90          |
| 39.6  | Sr-91   | Y-91m         |
| 39.7  | Sr-92   | Y-92          |
| 39.8  | Y-87    | Sr-87m        |
| 39.9  | Zr-95   | Nb-95m        |
| 39.10 | Zr-97   | Nb-97m, Nb-97 |
| 39.11 | Mo-99   | Tc-99m        |
| 39.12 | Tc-95m  | Tc-95         |
| 39.13 | Tc-96m  | Tc-96         |
| 39.14 | Ru-103  | Rh-103m       |
| 39.15 | Ru-106  | Rh-106        |
| 39.16 | Pd-103  | Rh-103m       |
| 39.17 | Ag-108m | Ag-108        |
| 39.18 | Ag-110m | Ag-110        |
| 39.19 | Cd-115  | In-115m       |
| 39.20 | In-114m | In-114        |
| 39.21 | Sn-113  | In-113m       |
| 39.22 | Sn-121m | Sn-121        |
| 39.23 | Sn-126  | Sb-126m       |
| 39.24 | Te-127m | Te-127        |
| 39.25 | Te-129m | Te-129        |
| 39.26 | Te-131m | Te-131        |
| 39.27 | Te-132  | I-132         |
| 39.28 | I-135   | Xe-135m       |
| 39.29 | Xe-122  | I-122         |

|       |         |                                         |
|-------|---------|-----------------------------------------|
| 40.1  | Cs-137  | Ba-137m                                 |
| 40.2  | Ba-131  | Cs-131                                  |
| 40.3  | Ba-140  | La-140                                  |
| 40.4  | Ce-144  | Pr-144m, Pr-144                         |
| 40.5  | Pm-148M | Pm-148                                  |
| 40.6  | Gd-146  | Eu-146                                  |
| 40.7  | Dy-166  | Ho-166                                  |
| 40.8  | Hf-172  | Lu-172                                  |
| 40.9  | W-178   | Ta-178                                  |
| 40.10 | W-188   | Re-188                                  |
| 40.11 | Re-189  | Os-189m                                 |
| 40.12 | Os-194  | Ir-194                                  |
| 40.13 | Ir-189  | Os-189m                                 |
| 40.14 | Pt-188  | Ir-188                                  |
| 40.15 | Hg-194  | Au-194                                  |
| 40.16 | Hg-195m | Hg-195                                  |
| 40.17 | Pb-210  | Bi-210                                  |
| 40.18 | Pb-212  | Bi-212, Tl-208, Po-212                  |
| 40.19 | Bi-210m | Tl-206                                  |
| 40.20 | Bi-212  | Tl-208, Po-212                          |
| 40.21 | At-211  | Po-211                                  |
| 40.22 | Rn-222  | Po-218, Pb-214, At-218, Bi-214, Po-214  |
| 40.23 | Ra-223  | Rn-219, Po-215, Pb-211, Bi-211, Po-211, |
| 40.24 |         | Tl-207                                  |
| 40.25 | Ra-224  | Rn-220, Po-216, Pb-212, Bi-212, Tl-208, |
| 40.26 |         | Po-212                                  |
| 40.27 | Ra-225  | Ac-225, Fr-221, At-217, Bi-213, Tl-209, |
| 40.28 |         | Po-213, Pb-209                          |
| 40.29 | Ra-226  | Rn-222, Po-218, Pb-214, At-218, Bi-214, |
| 40.30 |         | Po-214                                  |

|       |                                                                                                         |                                         |
|-------|---------------------------------------------------------------------------------------------------------|-----------------------------------------|
| 41.1  | Ra-228                                                                                                  | Ac-228                                  |
| 41.2  | Ac-225                                                                                                  | Fr-221, At-217, Bi-213, Tl-209, Po-213, |
| 41.3  |                                                                                                         | Pb-209                                  |
| 41.4  | Ac-227                                                                                                  | Fr-223                                  |
| 41.5  | Th-228                                                                                                  | Ra-224, Rn-220, Po-216, Pb-212, Bi-212, |
| 41.6  |                                                                                                         | Tl-208, Po-212                          |
| 41.7  | Th-234                                                                                                  | Pa-234m, Pa-234                         |
| 41.8  | Pa-230                                                                                                  | Ac-226, Th-226, Fr-222, Ra-222, Rn-218, |
| 41.9  |                                                                                                         | Po-214                                  |
| 41.10 | U-230                                                                                                   | Th-226, Ra-222, Rn-218, Po-214          |
| 41.11 | U-235                                                                                                   | Th-231                                  |
| 41.12 | Pu-241                                                                                                  | U-237                                   |
| 41.13 | Pu-244                                                                                                  | U-240, Np-240m                          |
| 41.14 | Am-242m                                                                                                 | Am-242, Np-238                          |
| 41.15 | Am-243                                                                                                  | Np-239                                  |
| 41.16 | Cm-247                                                                                                  | Pu-243                                  |
| 41.17 | Bk-249                                                                                                  | Am-245                                  |
| 41.18 | Cf-253                                                                                                  | Cm-249                                  |
| 41.19 | <sup>b</sup> The values of $A_1$ and $A_2$ in curies (Ci) are approximate and for information only; the |                                         |
| 41.20 | regulatory standard units are Terabecquerels (TBq). See part 4731.0423, subpart 1 -                     |                                         |
| 41.21 | Determination of $A_1$ and $A_2$ .                                                                      |                                         |
| 41.22 | <sup>c</sup> The activity of Ir-192 in special form may be determined from a measurement of the rate    |                                         |
| 41.23 | of decay or a measurement of the radiation level at a prescribed distance from the source.              |                                         |
| 41.24 | <sup>d</sup> These values apply only to compounds of uranium that take the chemical form of $UF_6$ ,    |                                         |
| 41.25 | $UO_2F_2$ , and $UO_2(NO_3)_2$ in both normal and accident conditions of transport.                     |                                         |
| 41.26 | <sup>e</sup> These values apply only to compounds of uranium that take the chemical form of $UO_3$ ,    |                                         |
| 41.27 | $UF_4$ , and $UCl_4$ and hexavalent compounds in both normal and accident conditions of                 |                                         |
| 41.28 | transport.                                                                                              |                                         |

- 42.1 <sup>f</sup>These values apply to all compounds of uranium other than those specified in notes d and
- 42.2 e.
- 42.3 <sup>g</sup>These values apply to unirradiated uranium only.
- 42.4 <sup>h</sup>A<sub>2</sub> = 0.74 TBq (20 Ci) for Mo-99 for domestic use.

42.5 Subp. 2. **Specific activity.** This subpart specifies specific activity for individual

42.6 radionuclides.

| 42.7  | Element and Atomic   | Specific Activity    |                      |
|-------|----------------------|----------------------|----------------------|
| 42.8  | Number and Symbol of |                      |                      |
| 42.9  | Radionuclide         |                      |                      |
| 42.10 |                      | (TBq/g)              | (Ci/g)               |
| 42.11 | Actinium (89)        |                      |                      |
| 42.12 | Ac-225               | $2.1 \times 10^3$    | $5.8 \times 10^4$    |
| 42.13 | Ac-227               | 2.7                  | $7.2 \times 10^1$    |
| 42.14 | Ac-228               | $8.4 \times 10^4$    | $2.2 \times 10^6$    |
| 42.15 | Silver (47)          |                      |                      |
| 42.16 | Ag-105               | $1.1 \times 10^3$    | $3.0 \times 10^4$    |
| 42.17 | Ag-108m              | $9.7 \times 10^{-1}$ | $2.6 \times 10^1$    |
| 42.18 | Ag-110m              | $1.8 \times 10^2$    | $4.7 \times 10^3$    |
| 42.19 | Ag-111               | $5.8 \times 10^3$    | $1.6 \times 10^5$    |
| 42.20 | Aluminum (13)        |                      |                      |
| 42.21 | Al-26                | $7.0 \times 10^{-4}$ | $1.9 \times 10^{-2}$ |
| 42.22 | Americium (95)       |                      |                      |
| 42.23 | Am-241               | $1.3 \times 10^{-1}$ | 3.4                  |
| 42.24 | Am-242m              | $3.6 \times 10^{-1}$ | $1.0 \times 10^1$    |
| 42.25 | Am-243               | $7.4 \times 10^{-3}$ | $2.0 \times 10^{-1}$ |
| 42.26 | Argon (18)           |                      |                      |

|       |               |                      |                      |
|-------|---------------|----------------------|----------------------|
| 43.1  | Ar-37         | $3.7 \times 10^3$    | $9.9 \times 10^4$    |
| 43.2  | Ar-39         | 1.3                  | $3.4 \times 10^1$    |
| 43.3  | Ar-41         | $1.5 \times 10^6$    | $4.2 \times 10^7$    |
| 43.4  | Ar-42         | 9.6                  | $2.6 \times 10^2$    |
| 43.5  | Arsenic (33)  |                      |                      |
| 43.6  | As-72         | $6.2 \times 10^4$    | $1.7 \times 10^6$    |
| 43.7  | As-73         | $8.2 \times 10^2$    | $2.2 \times 10^4$    |
| 43.8  | As-74         | $3.7 \times 10^3$    | $9.9 \times 10^4$    |
| 43.9  | As-76         | $5.8 \times 10^4$    | $1.6 \times 10^6$    |
| 43.10 | As-77         | $3.9 \times 10^4$    | $1.0 \times 10^6$    |
| 43.11 | Astatine (85) |                      |                      |
| 43.12 | At-211        | $7.6 \times 10^4$    | $2.1 \times 10^6$    |
| 43.13 | Gold (79)     |                      |                      |
| 43.14 | Au-193        | $3.4 \times 10^4$    | $9.2 \times 10^5$    |
| 43.15 | Au-194        | $1.5 \times 10^4$    | $4.1 \times 10^5$    |
| 43.16 | Au-195        | $1.4 \times 10^2$    | $3.7 \times 10^3$    |
| 43.17 | Au-196        | $4.0 \times 10^3$    | $1.1 \times 10^5$    |
| 43.18 | Au-198        | $9.0 \times 10^3$    | $2.4 \times 10^5$    |
| 43.19 | Au-199        | $7.7 \times 10^3$    | $2.1 \times 10^5$    |
| 43.20 | Barium (56)   |                      |                      |
| 43.21 | Ba-131        | $3.1 \times 10^3$    | $8.4 \times 10^4$    |
| 43.22 | Ba-133m       | $2.2 \times 10^4$    | $6.1 \times 10^5$    |
| 43.23 | Ba-133        | 9.4                  | $2.6 \times 10^2$    |
| 43.24 | Ba-140        | $2.7 \times 10^3$    | $7.3 \times 10^4$    |
| 43.25 | Beryllium (4) |                      |                      |
| 43.26 | Be-7          | $1.3 \times 10^4$    | $3.5 \times 10^5$    |
| 43.27 | Be-10         | $8.3 \times 10^{-4}$ | $2.2 \times 10^{-2}$ |

|       |                |                      |                      |
|-------|----------------|----------------------|----------------------|
| 44.1  | Bismuth (83)   |                      |                      |
| 44.2  | Bi-205         | $1.5 \times 10^3$    | $4.2 \times 10^4$    |
| 44.3  | Bi-206         | $3.8 \times 10^3$    | $1.0 \times 10^5$    |
| 44.4  | Bi-207         | 1.9                  | $5.2 \times 10^1$    |
| 44.5  | Bi-210m        | $2.1 \times 10^{-5}$ | $5.7 \times 10^{-4}$ |
| 44.6  | Bi-210         | $4.6 \times 10^3$    | $1.2 \times 10^5$    |
| 44.7  | Bi-212         | $5.4 \times 10^5$    | $1.5 \times 10^7$    |
| 44.8  | Berkelium (97) |                      |                      |
| 44.9  | Bk-247         | $3.8 \times 10^{-2}$ | 1.0                  |
| 44.10 | Bk-249         | $6.1 \times 10^1$    | $1.6 \times 10^3$    |
| 44.11 | Bromine (35)   |                      |                      |
| 44.12 | Br-76          | $9.4 \times 10^4$    | $2.5 \times 10^6$    |
| 44.13 | Br-77          | $2.6 \times 10^4$    | $7.1 \times 10^5$    |
| 44.14 | Br-82          | $4.0 \times 10^4$    | $1.1 \times 10^6$    |
| 44.15 | Carbon (6)     |                      |                      |
| 44.16 | C-11           | $3.1 \times 10^7$    | $8.4 \times 10^8$    |
| 44.17 | C-14           | $1.6 \times 10^{-1}$ | 4.5                  |
| 44.18 | Calcium (20)   |                      |                      |
| 44.19 | Ca-41          | $3.1 \times 10^{-3}$ | $8.5 \times 10^{-2}$ |
| 44.20 | Ca-45          | $6.6 \times 10^2$    | $1.8 \times 10^4$    |
| 44.21 | Ca-47          | $2.3 \times 10^4$    | $6.1 \times 10^5$    |
| 44.22 | Cadmium (48)   |                      |                      |
| 44.23 | Cd-109         | $9.6 \times 10^1$    | $2.6 \times 10^3$    |
| 44.24 | Cd-113m        | 8.3                  | $2.2 \times 10^2$    |
| 44.25 | Cd-115m        | $9.4 \times 10^2$    | $2.5 \times 10^4$    |
| 44.26 | Cd-115         | $1.9 \times 10^4$    | $5.1 \times 10^5$    |
| 44.27 | Cerium (58)    |                      |                      |

|       |                  |                      |                      |
|-------|------------------|----------------------|----------------------|
| 45.1  | Ce-139           | $2.5 \times 10^2$    | $6.8 \times 10^3$    |
| 45.2  | Ce-141           | $1.1 \times 10^3$    | $2.8 \times 10^4$    |
| 45.3  | Ce-143           | $2.5 \times 10^4$    | $6.6 \times 10^5$    |
| 45.4  | Ce-144           | $1.2 \times 10^2$    | $3.2 \times 10^3$    |
| 45.5  | Californium (98) |                      |                      |
| 45.6  | Cf-248           | $5.8 \times 10^1$    | $1.6 \times 10^3$    |
| 45.7  | Cf-249           | $1.5 \times 10^{-1}$ | 4.1                  |
| 45.8  | Cf-250           | 4.0                  | $1.1 \times 10^2$    |
| 45.9  | Cf-251           | $5.9 \times 10^{-2}$ | 1.6                  |
| 45.10 | Cf-252           | $2.0 \times 10^1$    | $5.4 \times 10^2$    |
| 45.11 | Cf-253           | $1.1 \times 10^3$    | $2.9 \times 10^4$    |
| 45.12 | Cf-254           | $3.1 \times 10^2$    | $8.5 \times 10^3$    |
| 45.13 | Chlorine (17)    |                      |                      |
| 45.14 | Cl-36            | $1.2 \times 10^{-3}$ | $3.3 \times 10^{-2}$ |
| 45.15 | Cl-38            | $4.9 \times 10^6$    | $1.3 \times 10^8$    |
| 45.16 | Curium (96)      |                      |                      |
| 45.17 | Cm-240           | $7.5 \times 10^2$    | $2.0 \times 10^4$    |
| 45.18 | Cm-241           | $6.1 \times 10^2$    | $1.7 \times 10^4$    |
| 45.19 | Cm-242           | $1.2 \times 10^2$    | $3.3 \times 10^3$    |
| 45.20 | Cm-243           | $1.9 \times 10^{-3}$ | $5.2 \times 10^1$    |
| 45.21 | Cm-244           | 3.0                  | $8.1 \times 10^1$    |
| 45.22 | Cm-245           | $6.4 \times 10^{-3}$ | $1.7 \times 10^{-1}$ |
| 45.23 | Cm-246           | $1.1 \times 10^{-2}$ | $3.1 \times 10^{-1}$ |
| 45.24 | Cm-247           | $3.4 \times 10^{-6}$ | $9.3 \times 10^{-5}$ |
| 45.25 | Cm-248           | $1.6 \times 10^{-4}$ | $4.2 \times 10^{-3}$ |
| 45.26 | Cobalt (27)      |                      |                      |
| 45.27 | Co-55            | $1.1 \times 10^5$    | $3.1 \times 10^6$    |

|       |                  |                      |                      |
|-------|------------------|----------------------|----------------------|
| 46.1  | Co-56            | $1.1 \times 10^3$    | $3.0 \times 10^4$    |
| 46.2  | Co-57            | $3.1 \times 10^2$    | $8.4 \times 10^3$    |
| 46.3  | Co-58m           | $2.2 \times 10^5$    | $5.9 \times 10^6$    |
| 46.4  | Co-58            | $1.2 \times 10^3$    | $3.2 \times 10^4$    |
| 46.5  | Co-60            | $4.2 \times 10^1$    | $1.1 \times 10^3$    |
| 46.6  | Chromium (24)    |                      |                      |
| 46.7  | Cr-51            | $3.4 \times 10^3$    | $9.2 \times 10^4$    |
| 46.8  | Cesium (55)      |                      |                      |
| 46.9  | Cs-129           | $2.8 \times 10^4$    | $7.6 \times 10^5$    |
| 46.10 | Cs-131           | $3.8 \times 10^3$    | $1.0 \times 10^5$    |
| 46.11 | Cs-132           | $5.7 \times 10^3$    | $1.5 \times 10^5$    |
| 46.12 | Cs-134m          | $3.0 \times 10^5$    | $8.0 \times 10^6$    |
| 46.13 | Cs-134           | $4.8 \times 10^1$    | $1.3 \times 10^3$    |
| 46.14 | Cs-135           | $4.3 \times 10^{-5}$ | $1.2 \times 10^{-3}$ |
| 46.15 | Cs-136           | $2.7 \times 10^3$    | $7.3 \times 10^4$    |
| 46.16 | Cs-137           | 3.2                  | $8.7 \times 10^1$    |
| 46.17 | Copper (29)      |                      |                      |
| 46.18 | Cu-64            | $1.4 \times 10^5$    | $3.9 \times 10^6$    |
| 46.19 | Cu-67            | $2.8 \times 10^4$    | $7.6 \times 10^5$    |
| 46.20 | Dysprosium (66)  |                      |                      |
| 46.21 | Dy-159           | $2.1 \times 10^2$    | $5.7 \times 10^3$    |
| 46.22 | Dy-165           | $3.0 \times 10^5$    | $8.2 \times 10^6$    |
| 46.23 | Dy-166           | $8.6 \times 10^3$    | $2.3 \times 10^5$    |
| 46.24 | Erbium (68)      |                      |                      |
| 46.25 | Er-169           | $3.1 \times 10^3$    | $8.3 \times 10^4$    |
| 46.26 | Er-171           | $9.0 \times 10^4$    | $2.4 \times 10^6$    |
| 46.27 | Einsteinium (99) |                      |                      |

|       |               |                      |                      |
|-------|---------------|----------------------|----------------------|
| 47.1  | Es-253        | ---                  | ---                  |
| 47.2  | Es-254        | ---                  | ---                  |
| 47.3  | Es-254m       | ---                  | ---                  |
| 47.4  | Es-255        | ---                  | ---                  |
| 47.5  | Europium (63) |                      |                      |
| 47.6  | Eu-147        | $1.4 \times 10^3$    | $3.7 \times 10^4$    |
| 47.7  | Eu-148        | $6.0 \times 10^2$    | $1.6 \times 10^4$    |
| 47.8  | Eu-149        | $3.5 \times 10^2$    | $9.4 \times 10^3$    |
| 47.9  | Eu-150        | $6.1 \times 10^4$    | $1.6 \times 10^6$    |
| 47.10 | Eu-152m       | $8.2 \times 10^4$    | $2.2 \times 10^6$    |
| 47.11 | Eu-152        | 6.5                  | $1.8 \times 10^2$    |
| 47.12 | Eu-154        | 9.8                  | $2.6 \times 10^2$    |
| 47.13 | Eu-155        | $1.8 \times 10^1$    | $4.9 \times 10^2$    |
| 47.14 | Eu-156        | $2.0 \times 10^3$    | $5.5 \times 10^4$    |
| 47.15 | Fluorine (9)  |                      |                      |
| 47.16 | F-18          | $3.5 \times 10^6$    | $9.5 \times 10^7$    |
| 47.17 | Iron (26)     |                      |                      |
| 47.18 | Fe-52         | $2.7 \times 10^5$    | $7.3 \times 10^6$    |
| 47.19 | Fe-55         | $8.8 \times 10^1$    | $2.4 \times 10^3$    |
| 47.20 | Fe-59         | $1.8 \times 10^3$    | $5.0 \times 10^4$    |
| 47.21 | Fe-60         | $7.4 \times 10^{-4}$ | $2.0 \times 10^{-2}$ |
| 47.22 | Fermium (100) |                      |                      |
| 47.23 | Fm-255        | ---                  | ---                  |
| 47.24 | Fm-257        | ---                  | ---                  |
| 47.25 | Gallium (31)  |                      |                      |
| 47.26 | Ga-67         | $2.2 \times 10^4$    | $6.0 \times 10^5$    |
| 47.27 | Ga-68         | $1.5 \times 10^6$    | $4.1 \times 10^7$    |

|       |                 |                      |                      |
|-------|-----------------|----------------------|----------------------|
| 48.1  | Ga-72           | $1.1 \times 10^5$    | $3.1 \times 10^6$    |
| 48.2  | Gadolinium (64) |                      |                      |
| 48.3  | Gd-146          | $6.9 \times 10^2$    | $1.9 \times 10^4$    |
| 48.4  | Gd-148          | 1.2                  | $3.2 \times 10^1$    |
| 48.5  | Gd-153          | $1.3 \times 10^2$    | $3.5 \times 10^3$    |
| 48.6  | Gd-159          | $3.9 \times 10^4$    | $1.1 \times 10^6$    |
| 48.7  | Germanium (32)  |                      |                      |
| 48.8  | Ge-68           | $2.6 \times 10^2$    | $7.1 \times 10^3$    |
| 48.9  | Ge-71           | $5.8 \times 10^3$    | $1.6 \times 10^5$    |
| 48.10 | Ge-77           | $1.3 \times 10^5$    | $3.6 \times 10^6$    |
| 48.11 | Hydrogen (1)    |                      |                      |
| 48.12 | H-3 (T)         | $3.6 \times 10^2$    | $9.7 \times 10^3$    |
| 48.13 | Hafnium (72)    |                      |                      |
| 48.14 | Hf-172          | $4.1 \times 10^1$    | $1.1 \times 10^3$    |
| 48.15 | Hf-175          | $3.9 \times 10^2$    | $1.1 \times 10^4$    |
| 48.16 | Hf-181          | $6.3 \times 10^2$    | $1.7 \times 10^4$    |
| 48.17 | Hf-182          | $8.1 \times 10^{-6}$ | $2.2 \times 10^{-4}$ |
| 48.18 | Mercury (80)    |                      |                      |
| 48.19 | Hg-194          | $1.3 \times 10^{-1}$ | 3.5                  |
| 48.20 | Hg-195m         | $1.5 \times 10^4$    | $4.0 \times 10^5$    |
| 48.21 | Hg-197m         | $2.5 \times 10^4$    | $6.7 \times 10^5$    |
| 48.22 | Hg-197          | $9.2 \times 10^3$    | $2.5 \times 10^5$    |
| 48.23 | Hg-203          | $5.1 \times 10^2$    | $1.4 \times 10^4$    |
| 48.24 | Holmium (67)    |                      |                      |
| 48.25 | Ho-163          | 2.7                  | $7.6 \times 10^1$    |
| 48.26 | Ho-166m         | $6.6 \times 10^{-2}$ | 1.8                  |
| 48.27 | Ho-166          | $2.6 \times 10^4$    | $7.0 \times 10^5$    |

## 49.1 Iodine (53)

|       |       |                      |                      |
|-------|-------|----------------------|----------------------|
| 49.2  | I-123 | $7.1 \times 10^4$    | $1.9 \times 10^6$    |
| 49.3  | I-124 | $9.3 \times 10^3$    | $2.5 \times 10^5$    |
| 49.4  | I-125 | $6.4 \times 10^2$    | $1.7 \times 10^4$    |
| 49.5  | I-126 | $2.9 \times 10^3$    | $8.0 \times 10^4$    |
| 49.6  | I-129 | $6.5 \times 10^{-6}$ | $1.8 \times 10^{-4}$ |
| 49.7  | I-131 | $4.6 \times 10^3$    | $1.2 \times 10^5$    |
| 49.8  | I-132 | $3.8 \times 10^5$    | $1.0 \times 10^7$    |
| 49.9  | I-133 | $4.2 \times 10^4$    | $1.1 \times 10^6$    |
| 49.10 | I-134 | $9.9 \times 10^5$    | $2.7 \times 10^7$    |
| 49.11 | I-135 | $1.3 \times 10^5$    | $3.5 \times 10^6$    |

## 49.12 Indium (49)

|       |         |                   |                   |
|-------|---------|-------------------|-------------------|
| 49.13 | In-111  | $1.5 \times 10^4$ | $4.2 \times 10^5$ |
| 49.14 | In-113m | $6.2 \times 10^5$ | $1.7 \times 10^7$ |
| 49.15 | In-114m | $8.6 \times 10^2$ | $2.3 \times 10^4$ |
| 49.16 | In-115m | $2.2 \times 10^5$ | $6.1 \times 10^6$ |

## 49.17 Iridium (77)

|       |         |                   |                   |
|-------|---------|-------------------|-------------------|
| 49.18 | Ir-189  | $1.9 \times 10^3$ | $5.2 \times 10^4$ |
| 49.19 | Ir-190  | $2.3 \times 10^3$ | $6.2 \times 10^4$ |
| 49.20 | Ir-192  | $3.4 \times 10^2$ | $9.2 \times 10^3$ |
| 49.21 | Ir-193m | $2.4 \times 10^3$ | $6.4 \times 10^4$ |
| 49.22 | Ir-194  | $3.1 \times 10^4$ | $8.4 \times 10^5$ |

## 49.23 Potassium (19)

|       |      |                      |                      |
|-------|------|----------------------|----------------------|
| 49.24 | K-40 | $2.4 \times 10^{-7}$ | $6.4 \times 10^{-6}$ |
| 49.25 | K-42 | $2.2 \times 10^5$    | $6.0 \times 10^6$    |
| 49.26 | K-43 | $1.2 \times 10^5$    | $3.3 \times 10^6$    |

## 49.27 Krypton (36)

|       |                 |                      |                      |
|-------|-----------------|----------------------|----------------------|
| 50.1  | Kr-79           | $4.2 \times 10^4$    | $1.1 \times 10^6$    |
| 50.2  | Kr-81           | $7.8 \times 10^{-4}$ | $2.1 \times 10^{-2}$ |
| 50.3  | Kr-85m          | $3.0 \times 10^5$    | $8.2 \times 10^6$    |
| 50.4  | Kr-85           | $1.5 \times 10^1$    | $3.9 \times 10^2$    |
| 50.5  | Kr-87           | $1.0 \times 10^6$    | $2.8 \times 10^7$    |
| 50.6  | Lanthanum (57)  |                      |                      |
| 50.7  | La-137          | $1.6 \times 10^{-3}$ | $4.4 \times 10^{-2}$ |
| 50.8  | La-140          | $2.1 \times 10^4$    | $5.6 \times 10^5$    |
| 50.9  | Lutetium (71)   |                      |                      |
| 50.10 | Lu-172          | $4.2 \times 10^3$    | $1.1 \times 10^5$    |
| 50.11 | Lu-173          | $5.6 \times 10^1$    | $1.5 \times 10^3$    |
| 50.12 | Lu-174m         | $2.0 \times 10^2$    | $5.3 \times 10^3$    |
| 50.13 | Lu-174          | $2.3 \times 10^1$    | $6.2 \times 10^2$    |
| 50.14 | Lu-177          | $4.1 \times 10^3$    | $1.1 \times 10^5$    |
| 50.15 | Magnesium (12)  |                      |                      |
| 50.16 | Mg-28           | $2.0 \times 10^5$    | $5.4 \times 10^6$    |
| 50.17 | Manganese (25)  |                      |                      |
| 50.18 | Mn-52           | $1.6 \times 10^4$    | $4.4 \times 10^5$    |
| 50.19 | Mn-53           | $6.8 \times 10^{-5}$ | $1.8 \times 10^{-3}$ |
| 50.20 | Mn-54           | $2.9 \times 10^2$    | $7.7 \times 10^3$    |
| 50.21 | Mn-56           | $8.0 \times 10^5$    | $2.2 \times 10^7$    |
| 50.22 | Molybdenum (42) |                      |                      |
| 50.23 | Mo-93           | $4.1 \times 10^{-2}$ | 1.1                  |
| 50.24 | Mo-99           | $1.8 \times 10^4$    | $4.8 \times 10^5$    |
| 50.25 | Nitrogen (7)    |                      |                      |
| 50.26 | N-13            | $5.4 \times 10^7$    | $1.5 \times 10^9$    |

|       |                |                      |                      |
|-------|----------------|----------------------|----------------------|
| 51.1  | Sodium (11)    |                      |                      |
| 51.2  | Na-22          | $2.3 \times 10^2$    | $6.3 \times 10^3$    |
| 51.3  | Na-24          | $3.2 \times 10^5$    | $8.7 \times 10^6$    |
| 51.4  | Niobium (41)   |                      |                      |
| 51.5  | Nb-92m         | $5.2 \times 10^3$    | $1.4 \times 10^5$    |
| 51.6  | Nb-93m         | 8.8                  | $2.4 \times 10^2$    |
| 51.7  | Nb-94          | $6.9 \times 10^{-3}$ | $1.9 \times 10^{-1}$ |
| 51.8  | Nb-95          | $1.5 \times 10^3$    | $3.9 \times 10^4$    |
| 51.9  | Nb-97          | $9.9 \times 10^5$    | $2.7 \times 10^7$    |
| 51.10 | Neodymium (60) |                      |                      |
| 51.11 | Nd-147         | $3.0 \times 10^3$    | $8.1 \times 10^4$    |
| 51.12 | Nd-149         | $4.5 \times 10^5$    | $1.2 \times 10^7$    |
| 51.13 | Nickel (28)    |                      |                      |
| 51.14 | Ni-59          | $3.0 \times 10^{-3}$ | $8.0 \times 10^{-2}$ |
| 51.15 | Ni-63          | 2.1                  | $5.7 \times 10^1$    |
| 51.16 | Ni-65          | $7.1 \times 10^5$    | $1.9 \times 10^7$    |
| 51.17 | Neptunium (93) |                      |                      |
| 51.18 | Np-235         | $5.2 \times 10^1$    | $1.4 \times 10^3$    |
| 51.19 | Np-236         | $4.7 \times 10^{-4}$ | $1.3 \times 10^{-2}$ |
| 51.20 | Np-237         | $2.6 \times 10^{-5}$ | $7.1 \times 10^{-4}$ |
| 51.21 | Np-239         | $8.6 \times 10^3$    | $2.3 \times 10^5$    |
| 51.22 | Osmium (76)    |                      |                      |
| 51.23 | Os-185         | $2.8 \times 10^2$    | $7.5 \times 10^3$    |
| 51.24 | Os-191m        | $4.6 \times 10^4$    | $1.3 \times 10^6$    |
| 51.25 | Os-191         | $1.6 \times 10^3$    | $4.4 \times 10^4$    |
| 51.26 | Os-193         | $2.0 \times 10^4$    | $5.3 \times 10^5$    |
| 51.27 | Os-194         | $1.1 \times 10^1$    | $3.1 \times 10^2$    |

|       |                   |                      |                      |
|-------|-------------------|----------------------|----------------------|
| 52.1  | Phosphorus (15)   |                      |                      |
| 52.2  | P-32              | $1.1 \times 10^4$    | $2.9 \times 10^5$    |
| 52.3  | P-33              | $5.8 \times 10^3$    | $1.6 \times 10^5$    |
| 52.4  | Protactinium (91) |                      |                      |
| 52.5  | Pa-230            | $1.2 \times 10^3$    | $3.3 \times 10^4$    |
| 52.6  | Pa-231            | $1.7 \times 10^{-3}$ | $4.7 \times 10^{-2}$ |
| 52.7  | Pa-233            | $7.7 \times 10^2$    | $2.1 \times 10^4$    |
| 52.8  | Lead (82)         |                      |                      |
| 52.9  | Pb-201            | $6.2 \times 10^4$    | $1.7 \times 10^6$    |
| 52.10 | Pb-202            | $1.2 \times 10^{-4}$ | $3.4 \times 10^{-3}$ |
| 52.11 | Pb-203            | $1.1 \times 10^4$    | $3.0 \times 10^5$    |
| 52.12 | Pb-205            | $4.5 \times 10^{-6}$ | $1.2 \times 10^{-4}$ |
| 52.13 | Pb-210            | 2.8                  | $7.6 \times 10^1$    |
| 52.14 | Pb-212            | $5.1 \times 10^4$    | $1.4 \times 10^6$    |
| 52.15 | Palladium (46)    |                      |                      |
| 52.16 | Pd-103            | $2.8 \times 10^3$    | $7.5 \times 10^4$    |
| 52.17 | Pd-107            | $1.9 \times 10^{-5}$ | $5.1 \times 10^{-4}$ |
| 52.18 | Pd-109            | $7.9 \times 10^4$    | $2.1 \times 10^6$    |
| 52.19 | Promethium (61)   |                      |                      |
| 52.20 | Pm-143            | $1.3 \times 10^2$    | $3.4 \times 10^3$    |
| 52.21 | Pm-144            | $9.2 \times 10^1$    | $2.5 \times 10^3$    |
| 52.22 | Pm-145            | 5.2                  | $1.4 \times 10^2$    |
| 52.23 | Pm-147            | $3.4 \times 10^1$    | $9.3 \times 10^2$    |
| 52.24 | Pm-148m           | $7.9 \times 10^2$    | $2.1 \times 10^4$    |
| 52.25 | Pm-149            | $1.5 \times 10^4$    | $4.0 \times 10^5$    |
| 52.26 | Pm-151            | $2.7 \times 10^4$    | $7.3 \times 10^5$    |
| 52.27 | Polonium (84)     |                      |                      |

|       |                   |                      |                      |
|-------|-------------------|----------------------|----------------------|
| 53.1  | Po-208            | $2.2 \times 10^1$    | $5.9 \times 10^2$    |
| 53.2  | Po-209            | $6.2 \times 10^{-1}$ | $1.7 \times 10^1$    |
| 53.3  | Po-210            | $1.7 \times 10^2$    | $4.5 \times 10^3$    |
| 53.4  | Praseodymium (59) |                      |                      |
| 53.5  | Pr-142            | $4.3 \times 10^4$    | $1.2 \times 10^6$    |
| 53.6  | Pr-143            | $2.5 \times 10^3$    | $6.7 \times 10^4$    |
| 53.7  | Platinum (78)     |                      |                      |
| 53.8  | Pt-188            | $2.5 \times 10^3$    | $6.8 \times 10^4$    |
| 53.9  | Pt-191            | $8.7 \times 10^3$    | $2.4 \times 10^5$    |
| 53.10 | Pt-193m           | $5.8 \times 10^3$    | $1.6 \times 10^5$    |
| 53.11 | Pt-193            | 1.4                  | $3.7 \times 10^1$    |
| 53.12 | Pt-195m           | $6.2 \times 10^3$    | $1.7 \times 10^5$    |
| 53.13 | Pt-197m           | $3.7 \times 10^5$    | $1.0 \times 10^7$    |
| 53.14 | Pt-197            | $3.2 \times 10^4$    | $8.7 \times 10^5$    |
| 53.15 | Plutonium (94)    |                      |                      |
| 53.16 | Pu-236            | $2.0 \times 10^1$    | $5.3 \times 10^2$    |
| 53.17 | Pu-237            | $4.5 \times 10^2$    | $1.2 \times 10^4$    |
| 53.18 | Pu-238            | $6.3 \times 10^{-1}$ | $1.7 \times 10^1$    |
| 53.19 | Pu-239            | $2.3 \times 10^{-3}$ | $6.2 \times 10^{-2}$ |
| 53.20 | Pu-240            | $8.4 \times 10^{-3}$ | $2.3 \times 10^{-1}$ |
| 53.21 | Pu-241            | 3.8                  | $1.0 \times 10^2$    |
| 53.22 | Pu-242            | $1.5 \times 10^{-4}$ | $3.9 \times 10^{-3}$ |
| 53.23 | Pu-244            | $6.7 \times 10^{-7}$ | $1.8 \times 10^{-5}$ |
| 53.24 | Radium (88)       |                      |                      |
| 53.25 | Ra-223            | $1.9 \times 10^3$    | $5.1 \times 10^4$    |
| 53.26 | Ra-224            | $5.9 \times 10^3$    | $1.6 \times 10^5$    |
| 53.27 | Ra-225            | $1.5 \times 10^3$    | $3.9 \times 10^4$    |

|       |               |                      |                      |
|-------|---------------|----------------------|----------------------|
| 54.1  | Ra-226        | $3.7 \times 10^{-2}$ | 1.0                  |
| 54.2  | Ra-228        | $1.0 \times 10^1$    | $2.7 \times 10^2$    |
| 54.3  | Rubidium (37) |                      |                      |
| 54.4  | Rb-81         | $3.1 \times 10^5$    | $8.4 \times 10^6$    |
| 54.5  | Rb-83         | $6.8 \times 10^2$    | $1.8 \times 10^4$    |
| 54.6  | Rb-84         | $1.8 \times 10^3$    | $4.7 \times 10^4$    |
| 54.7  | Rb-86         | $3.0 \times 10^3$    | $8.1 \times 10^4$    |
| 54.8  | Rb-87         | $3.2 \times 10^{-9}$ | $8.6 \times 10^{-8}$ |
| 54.9  | Rb (natural)  | $6.7 \times 10^6$    | $1.8 \times 10^8$    |
| 54.10 | Rhenium (75)  |                      |                      |
| 54.11 | Re-183        | $3.8 \times 10^2$    | $1.0 \times 10^4$    |
| 54.12 | Re-184m       | $1.6 \times 10^2$    | $4.3 \times 10^3$    |
| 54.13 | Re-184        | $6.9 \times 10^2$    | $1.9 \times 10^4$    |
| 54.14 | Re-186        | $6.9 \times 10^3$    | $1.9 \times 10^5$    |
| 54.15 | Re-187        | $1.4 \times 10^{-9}$ | $3.8 \times 10^{-8}$ |
| 54.16 | Re-188        | $3.6 \times 10^4$    | $9.8 \times 10^5$    |
| 54.17 | Re-189        | $2.5 \times 10^4$    | $6.8 \times 10^5$    |
| 54.18 | Re (natural)  | ---                  | $2.4 \times 10^{-8}$ |
| 54.19 | Rhodium (45)  |                      |                      |
| 54.20 | Rh-99         | $3.0 \times 10^3$    | $8.2 \times 10^4$    |
| 54.21 | Rh-101        | $4.1 \times 10^1$    | $1.1 \times 10^3$    |
| 54.22 | Rh-102m       | $2.3 \times 10^2$    | $6.2 \times 10^3$    |
| 54.23 | Rh-102        | $4.5 \times 10^1$    | $1.2 \times 10^3$    |
| 54.24 | Rh-103m       | $1.2 \times 10^6$    | $3.3 \times 10^7$    |
| 54.25 | Rh-105        | $3.1 \times 10^4$    | $8.4 \times 10^5$    |
| 54.26 | Radon (86)    |                      |                      |
| 54.27 | Rn-222        | $5.7 \times 10^3$    | $1.5 \times 10^5$    |

|       |                |                      |                      |
|-------|----------------|----------------------|----------------------|
| 55.1  | Ruthenium (44) |                      |                      |
| 55.2  | Ru-97          | $1.7 \times 10^4$    | $4.6 \times 10^5$    |
| 55.3  | Ru-103         | $1.2 \times 10^3$    | $3.2 \times 10^4$    |
| 55.4  | Ru-105         | $2.5 \times 10^5$    | $6.7 \times 10^6$    |
| 55.5  | Ru-106         | $1.2 \times 10^2$    | $3.3 \times 10^3$    |
| 55.6  | Sulfur (16)    |                      |                      |
| 55.7  | S-35           | $1.6 \times 10^3$    | $4.3 \times 10^4$    |
| 55.8  | Antimony (51)  |                      |                      |
| 55.9  | Sb-122         | $1.5 \times 10^4$    | $4.0 \times 10^5$    |
| 55.10 | Sb-124         | $6.5 \times 10^2$    | $1.7 \times 10^4$    |
| 55.11 | Sb-125         | $3.9 \times 10^1$    | $1.0 \times 10^3$    |
| 55.12 | Sb-126         | $3.1 \times 10^3$    | $8.4 \times 10^4$    |
| 55.13 | Scandium (21)  |                      |                      |
| 55.14 | Sc-44          | $6.7 \times 10^5$    | $1.8 \times 10^7$    |
| 55.15 | Sc-46          | $1.3 \times 10^3$    | $3.4 \times 10^4$    |
| 55.16 | Sc-47          | $3.1 \times 10^4$    | $8.3 \times 10^5$    |
| 55.17 | Sc-48          | $5.5 \times 10^4$    | $1.5 \times 10^6$    |
| 55.18 | Selenium (34)  |                      |                      |
| 55.19 | Se-75          | $5.4 \times 10^2$    | $1.5 \times 10^4$    |
| 55.20 | Se-79          | $2.6 \times 10^{-3}$ | $7.0 \times 10^{-2}$ |
| 55.21 | Silicon (14)   |                      |                      |
| 55.22 | Si-31          | $1.4 \times 10^6$    | $3.9 \times 10^7$    |
| 55.23 | Si-32          | 3.9                  | $1.1 \times 10^2$    |
| 55.24 | Samarium (62)  |                      |                      |
| 55.25 | Sm-145         | $9.8 \times 10^1$    | $2.6 \times 10^3$    |
| 55.26 | Sm-147         | $8.5 \times 10^{-1}$ | $2.3 \times 10^{-8}$ |
| 55.27 | Sm-151         | $9.7 \times 10^{-1}$ | $2.6 \times 10^1$    |

|       |                |                      |                      |
|-------|----------------|----------------------|----------------------|
| 56.1  | Sm-153         | $1.6 \times 10^4$    | $4.4 \times 10^5$    |
| 56.2  | Tin (50)       |                      |                      |
| 56.3  | Sn-113         | $3.7 \times 10^2$    | $1.0 \times 10^4$    |
| 56.4  | Sn-117m        | $3.0 \times 10^3$    | $8.2 \times 10^4$    |
| 56.5  | Sn-119m        | $1.4 \times 10^2$    | $3.7 \times 10^3$    |
| 56.6  | Sn-121m        | 2.0                  | $5.4 \times 10^1$    |
| 56.7  | Sn-123         | $3.0 \times 10^2$    | $8.2 \times 10^3$    |
| 56.8  | Sn-125         | $4.0 \times 10^3$    | $1.1 \times 10^5$    |
| 56.9  | Sn-126         | $1.0 \times 10^{-3}$ | $2.8 \times 10^{-2}$ |
| 56.10 | Strontium (38) |                      |                      |
| 56.11 | Sr-82          | $2.3 \times 10^3$    | $6.2 \times 10^4$    |
| 56.12 | Sr-85m         | $1.2 \times 10^6$    | $3.3 \times 10^7$    |
| 56.13 | Sr-85          | $8.8 \times 10^2$    | $2.4 \times 10^4$    |
| 56.14 | Sr-87m         | $4.8 \times 10^5$    | $1.3 \times 10^7$    |
| 56.15 | Sr-89          | $1.1 \times 10^3$    | $2.9 \times 10^4$    |
| 56.16 | Sr-90          | 5.1                  | $1.4 \times 10^2$    |
| 56.17 | Sr-91          | $1.3 \times 10^5$    | $3.6 \times 10^6$    |
| 56.18 | Sr-92          | $4.7 \times 10^5$    | $1.3 \times 10^7$    |
| 56.19 | Tritium (1)    |                      |                      |
| 56.20 | T (H-3)        | $3.6 \times 10^2$    | $9.7 \times 10^3$    |
| 56.21 | Tantalum (73)  |                      |                      |
| 56.22 | Ta-178         | $4.2 \times 10^6$    | $1.1 \times 10^8$    |
| 56.23 | Ta-179         | $4.1 \times 10^1$    | $1.1 \times 10^3$    |
| 56.24 | Ta-182         | $2.3 \times 10^2$    | $6.2 \times 10^3$    |
| 56.25 | Terbium (65)   |                      |                      |
| 56.26 | Tb-157         | $5.6 \times 10^{-1}$ | $1.5 \times 10^1$    |
| 56.27 | Tb-158         | $5.6 \times 10^{-1}$ | $1.5 \times 10^1$    |

|       |                 |                      |                      |
|-------|-----------------|----------------------|----------------------|
| 57.1  | Tb-160          | $4.2 \times 10^2$    | $1.1 \times 10^4$    |
| 57.2  | Technetium (43) |                      |                      |
| 57.3  | Tc-95m          | $8.3 \times 10^2$    | $2.2 \times 10^4$    |
| 57.4  | Tc-96m          | $1.4 \times 10^6$    | $3.8 \times 10^7$    |
| 57.5  | Tc-96           | $1.2 \times 10^4$    | $3.2 \times 10^5$    |
| 57.6  | Tc-97m          | $5.6 \times 10^2$    | $1.5 \times 10^4$    |
| 57.7  | Tc-97           | $5.2 \times 10^{-5}$ | $1.4 \times 10^{-3}$ |
| 57.8  | Tc-98           | $3.2 \times 10^{-5}$ | $8.7 \times 10^{-4}$ |
| 57.9  | Tc-99m          | $1.9 \times 10^5$    | $5.3 \times 10^6$    |
| 57.10 | Tc-99           | $6.3 \times 10^{-4}$ | $1.7 \times 10^{-2}$ |
| 57.11 | Tellurium (52)  |                      |                      |
| 57.12 | Te-118          | $6.8 \times 10^3$    | $1.8 \times 10^5$    |
| 57.13 | Te-121m         | $2.6 \times 10^2$    | $7.0 \times 10^3$    |
| 57.14 | Te-121          | $2.4 \times 10^3$    | $6.4 \times 10^4$    |
| 57.15 | Te-123m         | $3.3 \times 10^2$    | $8.9 \times 10^3$    |
| 57.16 | Te-125m         | $6.7 \times 10^2$    | $1.8 \times 10^4$    |
| 57.17 | Te-127m         | $3.5 \times 10^2$    | $9.4 \times 10^3$    |
| 57.18 | Te-127          | $9.8 \times 10^4$    | $2.6 \times 10^6$    |
| 57.19 | Te-129m         | $1.1 \times 10^3$    | $3.0 \times 10^4$    |
| 57.20 | Te-129          | $7.7 \times 10^5$    | $2.1 \times 10^7$    |
| 57.21 | Te-131m         | $3.0 \times 10^4$    | $8.0 \times 10^5$    |
| 57.22 | Te-132          | $1.1 \times 10^4$    | $3.0 \times 10^5$    |
| 57.23 | Thorium (90)    |                      |                      |
| 57.24 | Th-227          | $1.1 \times 10^3$    | $3.1 \times 10^4$    |
| 57.25 | Th-228          | $3.0 \times 10^1$    | $8.2 \times 10^2$    |
| 57.26 | Th-229          | $7.9 \times 10^{-3}$ | $2.1 \times 10^{-1}$ |
| 57.27 | Th-230          | $7.6 \times 10^{-4}$ | $2.1 \times 10^{-2}$ |
| 57.28 | Th-231          | $2.0 \times 10^4$    | $5.3 \times 10^5$    |

|       |                           |                      |                      |
|-------|---------------------------|----------------------|----------------------|
| 58.1  | Th-232                    | $4.0 \times 10^{-9}$ | $1.1 \times 10^{-7}$ |
| 58.2  | Th-234                    | $8.6 \times 10^2$    | $2.3 \times 10^4$    |
| 58.3  | Th (natural)              | $8.1 \times 10^{-9}$ | $2.2 \times 10^{-7}$ |
| 58.4  | Titanium (22)             |                      |                      |
| 58.5  | Ti-44                     | 6.4                  | $1.7 \times 10^2$    |
| 58.6  | Thallium (81)             |                      |                      |
| 58.7  | Tl-200                    | $2.2 \times 10^4$    | $6.0 \times 10^5$    |
| 58.8  | Tl-201                    | $7.9 \times 10^3$    | $2.1 \times 10^5$    |
| 58.9  | Tl-202                    | $2.0 \times 10^3$    | $5.3 \times 10^4$    |
| 58.10 | Tl-204                    | $1.7 \times 10^1$    | $4.6 \times 10^2$    |
| 58.11 | Thulium (69)              |                      |                      |
| 58.12 | Tm-167                    | $3.1 \times 10^3$    | $8.5 \times 10^4$    |
| 58.13 | Tm-168                    | $3.1 \times 10^2$    | $8.3 \times 10^3$    |
| 58.14 | Tm-170                    | $2.2 \times 10^2$    | $6.0 \times 10^3$    |
| 58.15 | Tm-171                    | $4.0 \times 10^1$    | $1.1 \times 10^3$    |
| 58.16 | Uranium (92)              |                      |                      |
| 58.17 | U-230                     | $1.0 \times 10^3$    | $2.7 \times 10^4$    |
| 58.18 | U-232                     | $8.3 \times 10^{-1}$ | $2.2 \times 10^1$    |
| 58.19 | U-233                     | $3.6 \times 10^{-4}$ | $9.7 \times 10^{-3}$ |
| 58.20 | U-234                     | $2.3 \times 10^{-4}$ | $6.2 \times 10^{-3}$ |
| 58.21 | U-235                     | $8.0 \times 10^{-8}$ | $2.2 \times 10^{-6}$ |
| 58.22 | U-236                     | $2.4 \times 10^{-6}$ | $6.5 \times 10^{-5}$ |
| 58.23 | U-238                     | $1.2 \times 10^{-8}$ | $3.4 \times 10^{-7}$ |
| 58.24 | U (natural)               | $2.6 \times 10^{-8}$ | $7.1 \times 10^{-7}$ |
| 58.25 | U (enriched 5% or less)   | ---                  | (See part 4731.0424) |
| 58.26 | U (enriched more than 5%) | ---                  | (See part 4731.0424) |
| 58.27 | U (depleted)              | ---                  | (See part 4731.0424) |

|       |                |                   |                   |
|-------|----------------|-------------------|-------------------|
| 59.1  | Vanadium (23)  |                   |                   |
| 59.2  | V-48           | $6.3 \times 10^3$ | $1.7 \times 10^5$ |
| 59.3  | V-49           | $3.0 \times 10^2$ | $8.1 \times 10^3$ |
| 59.4  | Tungsten (74)  |                   |                   |
| 59.5  | W-178          | $1.3 \times 10^3$ | $3.4 \times 10^4$ |
| 59.6  | W-181          | $2.2 \times 10^2$ | $6.0 \times 10^3$ |
| 59.7  | W-185          | $3.5 \times 10^2$ | $9.4 \times 10^3$ |
| 59.8  | W-187          | $2.6 \times 10^4$ | $7.0 \times 10^5$ |
| 59.9  | W-188          | $3.7 \times 10^2$ | $1.0 \times 10^4$ |
| 59.10 | Xenon (54)     |                   |                   |
| 59.11 | Xe-122         | $4.8 \times 10^4$ | $1.3 \times 10^6$ |
| 59.12 | Xe-123         | $4.4 \times 10^5$ | $1.2 \times 10^7$ |
| 59.13 | Xe-127         | $1.0 \times 10^3$ | $2.8 \times 10^4$ |
| 59.14 | Xe-131m        | $3.1 \times 10^3$ | $8.4 \times 10^4$ |
| 59.15 | Xe-133         | $6.9 \times 10^3$ | $1.9 \times 10^5$ |
| 59.16 | Xe-135         | $9.5 \times 10^4$ | $2.6 \times 10^6$ |
| 59.17 | Yttrium (39)   |                   |                   |
| 59.18 | Y-87           | $1.7 \times 10^4$ | $4.5 \times 10^5$ |
| 59.19 | Y-88           | $5.2 \times 10^2$ | $1.4 \times 10^4$ |
| 59.20 | Y-90           | $2.0 \times 10^4$ | $5.4 \times 10^5$ |
| 59.21 | Y-91m          | $1.5 \times 10^6$ | $4.2 \times 10^7$ |
| 59.22 | Y-91           | $9.1 \times 10^2$ | $2.5 \times 10^4$ |
| 59.23 | Y-92           | $3.6 \times 10^5$ | $9.6 \times 10^6$ |
| 59.24 | Y-93           | $1.2 \times 10^5$ | $3.3 \times 10^6$ |
| 59.25 | Ytterbium (70) |                   |                   |
| 59.26 | Yb-169         | $8.9 \times 10^2$ | $2.4 \times 10^4$ |
| 59.27 | Yb-175         | $6.6 \times 10^3$ | $1.8 \times 10^5$ |

## 60.1 Zinc (30)

|      |        |                   |                   |
|------|--------|-------------------|-------------------|
| 60.2 | Zn-65  | $3.0 \times 10^2$ | $8.2 \times 10^3$ |
| 60.3 | Zn-69m | $1.2 \times 10^5$ | $3.3 \times 10^6$ |
| 60.4 | Zn-69  | $1.8 \times 10^6$ | $4.9 \times 10^7$ |

## 60.5 Zirconium (40)

|      |       |                      |                      |
|------|-------|----------------------|----------------------|
| 60.6 | Zr-88 | $6.6 \times 10^2$    | $1.8 \times 10^4$    |
| 60.7 | Zr-93 | $9.3 \times 10^{-5}$ | $2.5 \times 10^{-3}$ |
| 60.8 | Zr-95 | $7.9 \times 10^2$    | $2.1 \times 10^4$    |
| 60.9 | Zr-97 | $7.1 \times 10^4$    | $1.9 \times 10^6$    |

- 60.10 Subp. 3. **Exempt material activity concentrations and exempt consignment activity**
- 60.11 **limits.** This subpart specifies exempt material activity concentrations and exempt
- 60.12 consignment activity levels for radionuclides.

| 60.13 | Element and atomic | Activity          | Activity          | Activity limit for | Activity limit for |
|-------|--------------------|-------------------|-------------------|--------------------|--------------------|
| 60.14 | number and symbol  | concentration for | concentration for | exempt             | exempt             |
| 60.15 | of radionuclide    | exempt material   | exempt material   | consignment        | consignment        |
| 60.16 |                    | (Bq/g)            | (Ci/g)            | (Bq)               | (Ci)               |

## 60.17 Actinium (89)

|       |        |                      |                       |                   |                      |
|-------|--------|----------------------|-----------------------|-------------------|----------------------|
| 60.18 | Ac-225 | $1.0 \times 10^1$    | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 60.19 | Ac-227 | $1.0 \times 10^{-1}$ | $2.7 \times 10^{-12}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 60.20 | Ac-228 | $1.0 \times 10^1$    | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

## 60.21 Silver (47)

|       |                      |                   |                       |                   |                      |
|-------|----------------------|-------------------|-----------------------|-------------------|----------------------|
| 60.22 | Ag-105               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 60.23 | Ag-108m <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 60.24 | Ag-110m              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 60.25 | Ag-111               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

## 60.26 Aluminum (13)

|       |       |                   |                       |                   |                      |
|-------|-------|-------------------|-----------------------|-------------------|----------------------|
| 60.27 | Al-26 | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
|-------|-------|-------------------|-----------------------|-------------------|----------------------|

|       |                      |                   |                       |                   |                      |
|-------|----------------------|-------------------|-----------------------|-------------------|----------------------|
| 61.1  | Americium (95)       |                   |                       |                   |                      |
| 61.2  | Am-241               | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 61.3  | Am-242m <sup>a</sup> | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 61.4  | Am-243 <sup>a</sup>  | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 61.5  | Argon (18)           |                   |                       |                   |                      |
| 61.6  | Ar-37                | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 61.7  | Ar-39                | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$  | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 61.8  | Ar-41                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 61.9  | Arsenic (33)         |                   |                       |                   |                      |
| 61.10 | As-72                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 61.11 | As-73                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 61.12 | As-74                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.13 | As-76                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 61.14 | As-77                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.15 | Astatine (85)        |                   |                       |                   |                      |
| 61.16 | At-211               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 61.17 | Gold (79)            |                   |                       |                   |                      |
| 61.18 | Au-193               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 61.19 | Au-194               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.20 | Au-195               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 61.21 | Au-198               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.22 | Au-199               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.23 | Barium (56)          |                   |                       |                   |                      |
| 61.24 | Ba-131               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.25 | Ba-133               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.26 | Ba-133m              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 61.27 | Ba-140 <sup>a</sup>  | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 62.1  | Beryllium (4)       |                   |                       |                   |                      |
| 62.2  | Be-7                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 62.3  | Be-10               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.4  | Bismuth (83)        |                   |                       |                   |                      |
| 62.5  | Bi-205              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.6  | Bi-206              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 62.7  | Bi-207              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.8  | Bi-210              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.9  | Bi-210m             | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 62.10 | Bi-212 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 62.11 | Berkelium (97)      |                   |                       |                   |                      |
| 62.12 | Bk-247              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 62.13 | Bk-249              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.14 | Bromine (35)        |                   |                       |                   |                      |
| 62.15 | Br-76               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 62.16 | Br-77               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.17 | Br-82               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.18 | Carbon(6)           |                   |                       |                   |                      |
| 62.19 | C-11                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.20 | C-14                | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 62.21 | Calcium (20)        |                   |                       |                   |                      |
| 62.22 | Ca-41               | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 62.23 | Ca-45               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 62.24 | Ca-47               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.25 | Cadmium (48)        |                   |                       |                   |                      |
| 62.26 | Cd-109              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 62.27 | Cd-113m             | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 63.1  | Cd-115              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.2  | Cd-115m             | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.3  | Cerium (58)         |                   |                       |                   |                      |
| 63.4  | Ce-139              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.5  | Ce-141              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 63.6  | Ce-143              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.7  | Ce-144 <sup>a</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 63.8  | Californium (98)    |                   |                       |                   |                      |
| 63.9  | Cf-248              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 63.10 | Cf-249              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 63.11 | Cf-250              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 63.12 | Cf-251              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 63.13 | Cf-252              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 63.14 | Cf-253              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 63.15 | Cf-254              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 63.16 | Chlorine (17)       |                   |                       |                   |                      |
| 63.17 | Cl-36               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.18 | Cl-38               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 63.19 | Curium (96)         |                   |                       |                   |                      |
| 63.20 | Cm-240              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 63.21 | Cm-241              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 63.22 | Cm-242              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 63.23 | Cm-243              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 63.24 | Cm-244              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 63.25 | Cm-245              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 63.26 | Cm-246              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 63.27 | Cm-247              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 64.1  | Cm-248              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 64.2  | Cobalt (27)         |                   |                       |                   |                      |
| 64.3  | Co-55               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.4  | Co-56               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.5  | Co-57               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.6  | Co-58               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.7  | Co-58m              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 64.8  | Co-60               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.9  | Chromium (24)       |                   |                       |                   |                      |
| 64.10 | Cr-51               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 64.11 | Cesium (55)         |                   |                       |                   |                      |
| 64.12 | Cs-129              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.13 | Cs-131              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.14 | Cs-132              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.15 | Cs-134              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 64.16 | Cs-134m             | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.17 | Cs-135              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 64.18 | Cs-136              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 64.19 | Cs-137 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 64.20 | Copper (29)         |                   |                       |                   |                      |
| 64.21 | Cu-64               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.22 | Cu-67               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.23 | Dysprosium (66)     |                   |                       |                   |                      |
| 64.24 | Dy-159              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 64.25 | Dy-165              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 64.26 | Dy-166              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

|       |                      |                   |                       |                   |                      |
|-------|----------------------|-------------------|-----------------------|-------------------|----------------------|
| 65.1  | Erbium (68)          |                   |                       |                   |                      |
| 65.2  | Er-169               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 65.3  | Er-171               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.4  | Europium (63)        |                   |                       |                   |                      |
| 65.5  | Eu-147               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.6  | Eu-148               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.7  | Eu-149               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 65.8  | Eu-150 (short-lived) | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.9  | Eu-150 (long-lived)  | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.10 | Eu-152               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.11 | Eu-152m              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.12 | Eu-154               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.13 | Eu-155               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 65.14 | Eu-156               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.15 | Fluorine (9)         |                   |                       |                   |                      |
| 65.16 | F-18                 | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.17 | Iron (26)            |                   |                       |                   |                      |
| 65.18 | Fe-52                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.19 | Fe-55                | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.20 | Fe-59                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.21 | Fe-60                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 65.22 | Gallium (31)         |                   |                       |                   |                      |
| 65.23 | Ga-67                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 65.24 | Ga-68                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 65.25 | Ga-72                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 65.26 | Gadolinium (64)      |                   |                       |                   |                      |
| 65.27 | Gd-146               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

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|----------|----------------|-------------------|-----------------------|-------------------|----------------------|
| 66.1     | Gd-148         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 66.2     | Gd-153         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 66.3     | Gd-159         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.4     | Germanium (32) |                   |                       |                   |                      |
| 66.5     | Ge-68          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 66.6     | Ge-71          | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 66.7     | Ge-77          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 66.8     | Tritium (1)    |                   |                       |                   |                      |
| 66.9     | H-3 (T)        | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 66.10    | Hafnium (72)   |                   |                       |                   |                      |
| 66.11    | Hf-172         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.12    | Hf-175         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.13    | Hf-181         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.14    | Hf-182         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.15    | Mercury (80)   |                   |                       |                   |                      |
| 66.16    | Hg-194         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.17    | Hg-195m        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.18    | Hg-197         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 66.19    | Hg-197m        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.20    | Hg-203         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 66.21    | Holmium (67)   |                   |                       |                   |                      |
| 66.22    | Ho-166         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 66.23    | Ho-166m        | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.24    | Iodine (53)    |                   |                       |                   |                      |
| 66.25    | I-123          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 66.26    | I-124          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 66.27    | I-125          | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

|       |                |                   |                       |                      |                      |
|-------|----------------|-------------------|-----------------------|----------------------|----------------------|
| 67.1  | I-126          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.2  | I-129          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 67.3  | I-131          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.4  | I-132          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 67.5  | I-133          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.6  | I-134          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 67.7  | I-135          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.8  | Indium (49)    |                   |                       |                      |                      |
| 67.9  | In-111         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.10 | In-113m        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.11 | In-114m        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.12 | In-115m        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.13 | Iridium (77)   |                   |                       |                      |                      |
| 67.14 | Ir-189         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$    | $2.7 \times 10^{-4}$ |
| 67.15 | Ir-190         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.16 | Ir-192         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 67.17 | Ir-194         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 67.18 | Potassium (19) |                   |                       |                      |                      |
| 67.19 | K-40           | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.20 | K-42           | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.21 | K-43           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 67.22 | Krypton (36)   |                   |                       |                      |                      |
| 67.23 | Kr-79          | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 67.24 | Kr-81          | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$    | $2.7 \times 10^{-4}$ |
| 67.25 | Kr-85          | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 67.26 | Kr-85m         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^{10}$ | $2.7 \times 10^{-1}$ |
| 67.27 | Kr-87          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^9$    | $2.7 \times 10^{-2}$ |

|       |                 |                   |                       |                   |                      |
|-------|-----------------|-------------------|-----------------------|-------------------|----------------------|
| 68.1  | Lanthanum (57)  |                   |                       |                   |                      |
| 68.2  | La-137          | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 68.3  | La-140          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 68.4  | Lutetium (71)   |                   |                       |                   |                      |
| 68.5  | Lu-172          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 68.6  | Lu-173          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 68.7  | Lu-174          | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 68.8  | Lu-174m         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 68.9  | Lu-177          | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 68.10 | Magnesium (12)  |                   |                       |                   |                      |
| 68.11 | Mg-28           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 68.12 | Manganese (25)  |                   |                       |                   |                      |
| 68.13 | Mn-52           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 68.14 | Mn-53           | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 68.15 | Mn-54           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 68.16 | Mn-56           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 68.17 | Molybdenum (42) |                   |                       |                   |                      |
| 68.18 | Mo-93           | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 68.19 | Mo-99           | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 68.20 | Nitrogen (7)    |                   |                       |                   |                      |
| 68.21 | N-13            | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 68.22 | Sodium (11)     |                   |                       |                   |                      |
| 68.23 | Na-22           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 68.24 | Na-24           | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 68.25 | Niobium (41)    |                   |                       |                   |                      |
| 68.26 | Nb-93m          | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |

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|----------|----------------------|-------------------|-----------------------|-------------------|----------------------|
| 69.1     | Nb-94                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.2     | Nb-95                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.3     | Nb-97                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.4     | Neodymium (60)       |                   |                       |                   |                      |
| 69.5     | Nd-147               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.6     | Nd-149               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.7     | Nickel (28)          |                   |                       |                   |                      |
| 69.8     | Ni-59                | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 69.9     | Ni-63                | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 69.10    | Ni-65                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.11    | Neptunium (93)       |                   |                       |                   |                      |
| 69.12    | Np-235               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 69.13    | Np-236 (short-lived) | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 69.14    | Np-236 (long-lived)  | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 69.15    | Np-237 <sup>a</sup>  | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 69.16    | Np-239               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 69.17    | Osmium (76)          |                   |                       |                   |                      |
| 69.18    | Os-185               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.19    | Os-191               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 69.20    | Os-191m              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 69.21    | Os-193               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 69.22    | Os-194               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 69.23    | Phosphorus (15)      |                   |                       |                   |                      |
| 69.24    | P-32                 | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 69.25    | P-33                 | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 69.26    | Protactinium (91)    |                   |                       |                   |                      |
| 69.27    | Pa-230               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

| 05/06/19 |                     |                   | REVISOR               | SGS/NB            | AR4477               |
|----------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 70.1     | Pa-231              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 70.2     | Pa-233              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 70.3     | Lead (82)           |                   |                       |                   |                      |
| 70.4     | Pb-201              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.5     | Pb-202              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.6     | Pb-203              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.7     | Pb-205              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 70.8     | Pb-210 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 70.9     | Pb-212 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 70.10    | Palladium (46)      |                   |                       |                   |                      |
| 70.11    | Pd-103              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 70.12    | Pd-107              | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 70.13    | Pd-109              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.14    | Promethium (61)     |                   |                       |                   |                      |
| 70.15    | Pm-143              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.16    | Pm-144              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.17    | Pm-145              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 70.18    | Pm-147              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 70.19    | Pm-148m             | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.20    | Pm-149              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.21    | Pm-151              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.22    | Polonium (84)       |                   |                       |                   |                      |
| 70.23    | Po-210              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 70.24    | Praseodymium (59)   |                   |                       |                   |                      |
| 70.25    | Pr-142              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 70.26    | Pr-143              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 70.27    | Platinum (78)       |                   |                       |                   |                      |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 71.1  | Pt-188              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.2  | Pt-191              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.3  | Pt-193              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 71.4  | Pt-193m             | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 71.5  | Pt-195m             | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.6  | Pt-197              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.7  | Pt-197m             | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.8  | Plutonium (94)      |                   |                       |                   |                      |
| 71.9  | Pu-236              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.10 | Pu-237              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 71.11 | Pu-238              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.12 | Pu-239              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.13 | Pu-240              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 71.14 | Pu-241              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.15 | Pu-242              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.16 | Pu-244              | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.17 | Radium (88)         |                   |                       |                   |                      |
| 71.18 | Ra-223 <sup>a</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.19 | Ra-224 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.20 | Ra-225              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.21 | Ra-226 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 71.22 | Ra-228 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.23 | Rubidium (37)       |                   |                       |                   |                      |
| 71.24 | Rb-81               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.25 | Rb-83               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.26 | Rb-84               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 71.27 | Rb-86               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 71.28 | Rb-87               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 72.1  | Rb (nat)            | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 72.2  | Rhenium (75)        |                   |                       |                   |                      |
| 72.3  | Re-184              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.4  | Re-184m             | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.5  | Re-186              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.6  | Re-187              | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 72.7  | Re-188              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 72.8  | Re-189              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.9  | Re (nat)            | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 72.10 | Rhodium (45)        |                   |                       |                   |                      |
| 72.11 | Rh-99               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.12 | Rh-101              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 72.13 | Rh-102              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.14 | Rh-102m             | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.15 | Rh-103m             | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 72.16 | Rh-105              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 72.17 | Radon (86)          |                   |                       |                   |                      |
| 72.18 | Rn-222 <sup>a</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 72.19 | Ruthenium (44)      |                   |                       |                   |                      |
| 72.20 | Ru-97               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 72.21 | Ru-103              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.22 | Ru-105              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 72.23 | Ru-106 <sup>a</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 72.24 | Sulfur (16)         |                   |                       |                   |                      |
| 72.25 | S-35                | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 72.26 | Antimony (51)       |                   |                       |                   |                      |
| 72.27 | Sb-122              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |

|       |               |                   |                       |                   |                      |
|-------|---------------|-------------------|-----------------------|-------------------|----------------------|
| 73.1  | Sb-124        | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.2  | Sb-125        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.3  | Sb-126        | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 73.4  | Scandium (21) |                   |                       |                   |                      |
| 73.5  | Sc-44         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 73.6  | Sc-46         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.7  | Sc-47         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.8  | Sc-48         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 73.9  | Selenium (34) |                   |                       |                   |                      |
| 73.10 | Se-75         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.11 | Se-79         | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 73.12 | Silicon (14)  |                   |                       |                   |                      |
| 73.13 | Si-31         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.14 | Si-32         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.15 | Samarium (62) |                   |                       |                   |                      |
| 73.16 | Sm-145        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 73.17 | Sm-147        | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 73.18 | Sm-151        | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 73.19 | Sm-153        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.20 | Tin (50)      |                   |                       |                   |                      |
| 73.21 | Sn-113        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 73.22 | Sn-117m       | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.23 | Sn-119m       | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 73.24 | Sn-121m       | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 73.25 | Sn-123        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 73.26 | Sn-125        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 73.27 | Sn-126        | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |

|       |                     |                   |                       |                   |                      |
|-------|---------------------|-------------------|-----------------------|-------------------|----------------------|
| 74.1  | Strontium (38)      |                   |                       |                   |                      |
| 74.2  | Sr-82               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 74.3  | Sr-85               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.4  | Sr-85m              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 74.5  | Sr-87m              | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.6  | Sr-89               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.7  | Sr-90 <sup>a</sup>  | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 74.8  | Sr-91               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 74.9  | Sr-92               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.10 | Tritium (1)         |                   |                       |                   |                      |
| 74.11 | T (H-3)             | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$  | $1.0 \times 10^9$ | $2.7 \times 10^{-2}$ |
| 74.12 | Tantalum (73)       |                   |                       |                   |                      |
| 74.13 | Ta-178 (long-lived) | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.14 | Ta-179              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 74.15 | Ta-182              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 74.16 | Terbium (65)        |                   |                       |                   |                      |
| 74.17 | Tb-157              | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 74.18 | Tb-158              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.19 | Tb-160              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.20 | Technetium (43)     |                   |                       |                   |                      |
| 74.21 | Tc-95m              | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.22 | Tc-96               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.23 | Tc-96m              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 74.24 | Tc-97               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 74.25 | Tc-97m              | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 74.26 | Tc-98               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 74.27 | Tc-99               | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |

|       |                       |                   |                       |                   |                      |
|-------|-----------------------|-------------------|-----------------------|-------------------|----------------------|
| 75.1  | Tc-99m                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.2  | Tellurium (52)        |                   |                       |                   |                      |
| 75.3  | Te-121                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.4  | Te-121m               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.5  | Te-123m               | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.6  | Te-125m               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.7  | Te-127                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.8  | Te-127m               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.9  | Te-129                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.10 | Te-129m               | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.11 | Te-131m               | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.12 | Te-132                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.13 | Thorium (90)          |                   |                       |                   |                      |
| 75.14 | Th-227                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 75.15 | Th-228 <sup>a</sup>   | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 75.16 | Th-229 <sup>a</sup>   | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 75.17 | Th-230                | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 75.18 | Th-231                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 75.19 | Th-232                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 75.20 | Th-234 <sup>a</sup>   | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 75.21 | Th (nat) <sup>a</sup> | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 75.22 | Titanium (22)         |                   |                       |                   |                      |
| 75.23 | Ti-44                 | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 75.24 | Thallium (81)         |                   |                       |                   |                      |
| 75.25 | Tl-200                | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.26 | Tl-201                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 75.27 | Tl-202                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |

|       |                               |                   |                       |                   |                      |
|-------|-------------------------------|-------------------|-----------------------|-------------------|----------------------|
| 76.1  | Tl-204                        | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.2  | Thulium (69)                  |                   |                       |                   |                      |
| 76.3  | Tm-167                        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 76.4  | Tm-170                        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 76.5  | Tm-171                        | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^8$ | $2.7 \times 10^{-3}$ |
| 76.6  | Uranium (92)                  |                   |                       |                   |                      |
| 76.7  | U-230 (fast lung              |                   |                       |                   |                      |
| 76.8  | absorption) <sup>a,b</sup>    | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 76.9  | U-230 (medium                 |                   |                       |                   |                      |
| 76.10 | lung absorption) <sup>c</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.11 | U-230 (slow lung              |                   |                       |                   |                      |
| 76.12 | absorption) <sup>d</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.13 | U-232 (fast lung              |                   |                       |                   |                      |
| 76.14 | absorption) <sup>a,b</sup>    | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 76.15 | U-232 (medium                 |                   |                       |                   |                      |
| 76.16 | lung absorption) <sup>c</sup> | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.17 | U-232 (slow lung              |                   |                       |                   |                      |
| 76.18 | absorption) <sup>d</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.19 | U-233 (fast lung              |                   |                       |                   |                      |
| 76.20 | absorption) <sup>b</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.21 | U-233 (medium                 |                   |                       |                   |                      |
| 76.22 | lung absorption) <sup>c</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 76.23 | U-233 (slow lung              |                   |                       |                   |                      |
| 76.24 | absorption) <sup>d</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 76.25 | U-234 (fast lung              |                   |                       |                   |                      |
| 76.26 | absorption) <sup>b</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 76.27 | U-234 (medium                 |                   |                       |                   |                      |
| 76.28 | lung absorption) <sup>c</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 76.29 | U-234 (slow lung              |                   |                       |                   |                      |
| 76.30 | absorption) <sup>d</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 76.31 | U-235 (all lung               |                   |                       |                   |                      |
| 76.32 | absorption                    |                   |                       |                   |                      |
| 76.33 | types) <sup>a,b,c,d</sup>     | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$ |

|       |                               |                   |                       |                      |                      |
|-------|-------------------------------|-------------------|-----------------------|----------------------|----------------------|
| 77.1  | U-236 (fast lung              |                   |                       |                      |                      |
| 77.2  | absorption) <sup>b</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 77.3  | U-236 (medium                 |                   |                       |                      |                      |
| 77.4  | lung absorption) <sup>c</sup> | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 77.5  | U-236 (slow lung              |                   |                       |                      |                      |
| 77.6  | absorption) <sup>d</sup>      | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 77.7  | U-238 (all lung               |                   |                       |                      |                      |
| 77.8  | absorption                    |                   |                       |                      |                      |
| 77.9  | types) <sup>a,b,c,d</sup>     | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 77.10 | U (nat) <sup>a</sup>          | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$    | $2.7 \times 10^{-8}$ |
| 77.11 | U (enriched to 20%            |                   |                       |                      |                      |
| 77.12 | or less) <sup>e</sup>         | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$    | $2.7 \times 10^{-8}$ |
| 77.13 | U (dep)                       | 1.0               | $2.7 \times 10^{-11}$ | $1.0 \times 10^3$    | $2.7 \times 10^{-8}$ |
|       |                               |                   |                       |                      |                      |
| 77.14 | Vanadium (23)                 |                   |                       |                      |                      |
| 77.15 | V-48                          | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 77.16 | V-49                          | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$    | $2.7 \times 10^{-4}$ |
|       |                               |                   |                       |                      |                      |
| 77.17 | Tungsten (74)                 |                   |                       |                      |                      |
| 77.18 | W-178                         | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 77.19 | W-181                         | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$    | $2.7 \times 10^{-4}$ |
| 77.20 | W-185                         | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^7$    | $2.7 \times 10^{-4}$ |
| 77.21 | W-187                         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$    | $2.7 \times 10^{-5}$ |
| 77.22 | W-188                         | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
|       |                               |                   |                       |                      |                      |
| 77.23 | Xenon (54)                    |                   |                       |                      |                      |
| 77.24 | Xe-122                        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^9$    | $2.7 \times 10^{-2}$ |
| 77.25 | Xe-123                        | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^9$    | $2.7 \times 10^{-2}$ |
| 77.26 | Xe-127                        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$    | $2.7 \times 10^{-6}$ |
| 77.27 | Xe-131m                       | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 77.28 | Xe-133                        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^4$    | $2.7 \times 10^{-7}$ |
| 77.29 | Xe-135                        | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^{10}$ | $2.7 \times 10^{-1}$ |

|       |                                                                                                       |                   |                       |                   |                      |
|-------|-------------------------------------------------------------------------------------------------------|-------------------|-----------------------|-------------------|----------------------|
| 78.1  | Yttrium (39)                                                                                          |                   |                       |                   |                      |
| 78.2  | Y-87                                                                                                  | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.3  | Y-88                                                                                                  | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.4  | Y-90                                                                                                  | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 78.5  | Y-91                                                                                                  | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.6  | Y-91m                                                                                                 | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.7  | Y-92                                                                                                  | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 78.8  | Y-93                                                                                                  | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 78.9  | Ytterbium (70)                                                                                        |                   |                       |                   |                      |
| 78.10 | Yb-169                                                                                                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 78.11 | Yb-175                                                                                                | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 78.12 | Zinc (30)                                                                                             |                   |                       |                   |                      |
| 78.13 | Zn-65                                                                                                 | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.14 | Zn-69                                                                                                 | $1.0 \times 10^4$ | $2.7 \times 10^{-7}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.15 | Zn-69m                                                                                                | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.16 | Zirconium (40)                                                                                        |                   |                       |                   |                      |
| 78.17 | Zr-88                                                                                                 | $1.0 \times 10^2$ | $2.7 \times 10^{-9}$  | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.18 | Zr-93 <sup>a</sup>                                                                                    | $1.0 \times 10^3$ | $2.7 \times 10^{-8}$  | $1.0 \times 10^7$ | $2.7 \times 10^{-4}$ |
| 78.19 | Zr-95                                                                                                 | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^6$ | $2.7 \times 10^{-5}$ |
| 78.20 | Zr-97 <sup>a</sup>                                                                                    | $1.0 \times 10^1$ | $2.7 \times 10^{-10}$ | $1.0 \times 10^5$ | $2.7 \times 10^{-6}$ |
| 78.21 | <sup>a</sup> Parent nuclides and their progeny included in secular equilibrium are listed as follows: |                   |                       |                   |                      |
| 78.22 | Sr-90                                                                                                 | Y-90              |                       |                   |                      |
| 78.23 | Zr-93                                                                                                 | Nb-93m            |                       |                   |                      |
| 78.24 | Zr-97                                                                                                 | Nb-97             |                       |                   |                      |
| 78.25 | Ru-106                                                                                                | Rh-106            |                       |                   |                      |
| 78.26 | Ag-108m                                                                                               | Ag-108            |                       |                   |                      |
| 78.27 | Cs-137                                                                                                | Ba-137m           |                       |                   |                      |

|       |          |                                                                      |
|-------|----------|----------------------------------------------------------------------|
| 79.1  | Ce-144   | Pr-144                                                               |
| 79.2  | Ba-140   | La-140                                                               |
| 79.3  | Bi-212   | Tl-208(0.36), Po-212(0.64)                                           |
| 79.4  | Pb-210   | Bi-210, Po-210                                                       |
| 79.5  | Pb-212   | Bi-212, Tl-208 (0.36), Po-212 (0.64)                                 |
| 79.6  | Rn-222   | Po-218, Pb-214, Bi-214, Po-214                                       |
| 79.7  | Ra-223   | Rn-219, Po-215, Pb-211, Bi-211, Tl-207                               |
| 79.8  | Ra-224   | Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)         |
| 79.9  | Ra-226   | Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210       |
| 79.10 | Ra-228   | Ac-228                                                               |
| 79.11 | Th-228   | Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64) |
| 79.12 | Th-229   | Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209               |
| 79.13 | Th (nat) | Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212,      |
| 79.14 |          | Tl-208 (0.36), Po-212 (0.64)                                         |
| 79.15 | Th-234   | Pa-234m                                                              |
| 79.16 | U-230    | Th-226, Ra-222, Rn-218, Po-214                                       |
| 79.17 | U-232    | Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36),       |
| 79.18 |          | Po-212 (0.64)                                                        |
| 79.19 | U-235    | Th-231                                                               |
| 79.20 | U-238    | Th-234, Pa-234m                                                      |
| 79.21 | U (nat)  | Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214,      |
| 79.22 |          | Bi-214, Po-214, Pb-210, Bi-210, Po-210                               |
| 79.23 | Np-237   | Pa-233                                                               |
| 79.24 | Am-242m  | Am-242                                                               |
| 79.25 | Am-243   | Np-239                                                               |

79.26 <sup>b</sup>These values apply only to compounds of uranium that take the chemical form of UF<sub>6</sub>,  
 79.27 UO<sub>2</sub>F<sub>2</sub> and UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> in both normal and accident conditions of transport.

79.28 <sup>c</sup>These values apply only to compounds of uranium that take the chemical form of UO<sub>3</sub>,  
 79.29 UF<sub>4</sub>, UCl<sub>4</sub> and hexavalent compounds in both normal and accident conditions of transport.

80.1 <sup>d</sup>These values apply to all compounds of uranium other than those specified in notes b and  
80.2 c of this table.

80.3 <sup>e</sup>These values apply to unirradiated uranium only.

80.4 **4731.0423 DETERMINATION OF A<sub>1</sub> AND A<sub>2</sub>.**

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

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

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

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

80.10 where B(i) is the activity of radionuclide i in special form and A<sub>1</sub>(i) is the A<sub>1</sub> value for  
80.11 radionuclide i.

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

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

80.14 where B(i) is the activity of radionuclide i in normal form and A<sub>2</sub>(i) is the A<sub>2</sub> value for  
80.15 radionuclide i.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

82.3 **Subp. 5. Activities unknown.**

82.4 A. When the identity of each radionuclide is known, but the individual activities  
 82.5 of some of the radionuclides are not known, the radionuclides may be grouped and the  
 82.6 lowest  $A_1$  or  $A_2$  value, as appropriate, for the radionuclides in each group may be used in  
 82.7 applying the formulas in subpart 4. Groups may be based on the total alpha activity and the  
 82.8 total beta/gamma activity when these are known, using the lowest  $A_1$  or  $A_2$  values for the  
 82.9 alpha emitters and beta/gamma emitters.

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

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

| 82.18 |                     | $A_1$              | $A_2$ |                    |                      |
|-------|---------------------|--------------------|-------|--------------------|----------------------|
| 82.19 | Contents            | (TBq)              | (Ci)  | (TBq)              | (Ci)                 |
| 82.20 | Only beta- or       |                    |       |                    |                      |
| 82.21 | gamma-emitting      |                    |       |                    |                      |
| 82.22 | radionuclides are   |                    |       |                    |                      |
| 82.23 | known to be present | $1 \times 10^{-1}$ | 2.7   | $2 \times 10^{-2}$ | $5.4 \times 10^{-1}$ |

|      |                                                                                                                   |                    |                      |                    |                      |
|------|-------------------------------------------------------------------------------------------------------------------|--------------------|----------------------|--------------------|----------------------|
| 83.1 | Alpha-emitting nuclides,                                                                                          |                    |                      |                    |                      |
| 83.2 | but no neutron emitters are                                                                                       |                    |                      |                    |                      |
| 83.3 | known to be present <sup>a</sup>                                                                                  | $2 \times 10^{-1}$ | 5.4                  | $9 \times 10^{-5}$ | $2.4 \times 10^{-3}$ |
| 83.4 | Neutron-emitting nuclides                                                                                         |                    |                      |                    |                      |
| 83.5 | are known to be present or                                                                                        |                    |                      |                    |                      |
| 83.6 | no relevant data are                                                                                              |                    |                      |                    |                      |
| 83.7 | available                                                                                                         | $1 \times 10^{-3}$ | $2.7 \times 10^{-2}$ | $9 \times 10^{-5}$ | $2.4 \times 10^{-3}$ |
| 83.8 | <sup>a</sup> If beta- or gamma-emitting nuclides are known to be present, the A <sub>1</sub> value of 0.1TBq (2.7 |                    |                      |                    |                      |
| 83.9 | Ci) should be used.                                                                                               |                    |                      |                    |                      |

|       |                             |                    |                       |                 |                      |
|-------|-----------------------------|--------------------|-----------------------|-----------------|----------------------|
| 83.10 |                             | Activity           |                       |                 |                      |
| 83.11 |                             | concentration      | Activity              | Activity limits | Activity limits      |
| 83.12 |                             | for exempt         | concentration         | for exempt      | for exempt           |
| 83.13 |                             | material           | for exempt            | consignments    | consignments         |
| 83.14 | Contents                    | (Bq/g)             | material (Ci/g)       | (Bq)            | (Ci)                 |
| 83.15 | Only beta- or               |                    |                       |                 |                      |
| 83.16 | gamma-emitting              |                    |                       |                 |                      |
| 83.17 | radionuclides are           |                    |                       |                 |                      |
| 83.18 | known to be present         | $1 \times 10^1$    | $2.7 \times 10^{-10}$ | $1 \times 10^4$ | $2.7 \times 10^{-7}$ |
| 83.19 | Alpha-emitting nuclides,    |                    |                       |                 |                      |
| 83.20 | but no neutron emitters are |                    |                       |                 |                      |
| 83.21 | known to be present         | $1 \times 10^{-1}$ | $2.7 \times 10^{-12}$ | $1 \times 10^3$ | $2.7 \times 10^{-8}$ |
| 83.22 | Neutron-emitting nuclides   |                    |                       |                 |                      |
| 83.23 | are known to be present or  |                    |                       |                 |                      |
| 83.24 | no relevant data are        |                    |                       |                 |                      |
| 83.25 | available                   | $1 \times 10^{-1}$ | $2.7 \times 10^{-12}$ | $1 \times 10^3$ | $2.7 \times 10^{-8}$ |

83.26 **4731.0565 APPLICATION; FILING.**

83.27 **Subpart 1. Generally.**

83.28 A. A person may apply for a specific license issued under parts 4731.0525 to

83.29 4731.0630 by filing an application according to part 4731.0200, subpart 4.

83.30 B. Applications and documents submitted to the commissioner in connection with

83.31 applications may be made available for public inspection according to part 4731.0240.

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

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

**Subpart 1. Requirements.**

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

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

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

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

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

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

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

85.1

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

85.4 Greater than  $10^4$  but less than or equal to  $10^5$  times the applicable  
85.5 quantities under part 4731.3160. For a combination of isotopes, if  
85.6 R, as defined in subpart 1, item A, divided by  $10^4$  is greater than  
85.7 1 but R divided by  $10^5$  is less than or equal to 1. \$1,125,000

85.8 Greater than  $10^3$  but less than or equal to  $10^4$  times the applicable  
85.9 quantities under part 4731.3160. For a combination of isotopes, if  
85.10 R, as defined in subpart 1, item A, divided by  $10^3$  is greater than  
85.11 1 but R divided by  $10^4$  is less than or equal to 1. \$225,000

85.12 [For text of subps 4 to 6, see M.R.]

85.13 **4731.0600 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.**

85.14 Subpart 1. **Expiration.**

85.15 A. A specific license issued under parts 4731.0525 to 4731.0630 expires at the  
85.16 end of the day on the expiration date stated in the license, unless the licensee has filed an  
85.17 application for renewal under part 4731.0595 not less than 30 days before the expiration  
85.18 date stated in the existing license.

85.19 B. If an application for renewal has been filed at least 30 days before the expiration  
85.20 date stated in the existing license, the existing license expires at the end of the day on which  
85.21 the commissioner makes a final determination to deny the renewal application or, if the  
85.22 determination states an expiration date, the expiration date stated in the determination.

85.23 Subp. 1a. **Revocation.** A specific license revoked by the commissioner expires at the  
85.24 end of the day on the date of the commissioner's final determination to revoke the license,  
85.25 on the expiration date stated in the determination, or as otherwise provided by a  
85.26 commissioner's order.

86.1 Subp. 1b. **Termination notice.** A specific license continues in effect, beyond the  
86.2 expiration date if necessary, with respect to possession of special nuclear material until the  
86.3 commissioner notifies the licensee in writing that the license is terminated. During this time,  
86.4 the licensee must:

86.5 (1) limit actions involving special nuclear material to those related to  
86.6 decommissioning; and

86.7 (2) continue to control entry to restricted areas until they are suitable for  
86.8 release according to this chapter.

86.9 Subp. 2. **Decommissioning.**

86.10 *[For text of items A to L, see M.R.]*

86.11 M. Specific licenses, including expired licenses, shall be terminated by written  
86.12 notice to the licensee when the commissioner determines that:

86.13 (1) special nuclear material has been properly disposed of;

86.14 (2) reasonable effort has been made to eliminate residual radioactive  
86.15 contamination, if present;

86.16 (3) a radiation survey has been performed that demonstrates, or other  
86.17 information submitted by the licensee is sufficient to demonstrate, that the premises are  
86.18 suitable for release according to parts 4731.2100 and 4731.2150; and

86.19 (4) records required by part 4731.0625 have been received.

86.20 Subp. 3. [See repealer.]

86.21 **4731.0610 AUTHORIZED USE OF SPECIAL NUCLEAR MATERIAL.**

86.22 Subpart 1. **Authority under license.** A licensee must confine the licensee's possession  
86.23 and use of special nuclear material to the locations and purposes authorized in the license.

87.1 Except as otherwise provided in the license, a license issued under this chapter carries with  
87.2 it the right to receive title to, own, acquire, receive, possess, and use special nuclear material.  
87.3 Preparation for shipment and transport of special nuclear material must be according to  
87.4 parts 4731.0400 to 4731.0424.

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

87.6 **4731.0620 REPORTING REQUIREMENTS.**

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

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

87.9 A. A licensee must make reports required under subparts 1 and 2 by telephone to  
87.10 the commissioner according to part 4731.0200, subpart 5. To the extent that the information  
87.11 is available at the time of notification, the information provided in the report must include:

87.12 *[For text of subitems (1) to (9), see M.R.]*

87.13 B. A licensee that makes a report required under subpart 1 or 2 must submit a  
87.14 written follow-up report within 30 days of the initial notification. Written reports prepared  
87.15 as required by other rules may be submitted to fulfill this requirement if the reports contain  
87.16 all of the necessary information. The written reports must be sent to the commissioner. The  
87.17 reports must include:

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

87.19 **4731.0760 SPECIFIC LICENSE; APPLICATION.**

87.20 **Subpart 1. Application generally.**

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

87.22 B. Applications and statements must be signed by the applicant or licensee or a  
87.23 person duly authorized to act for and on behalf of the applicant or licensee.

88.1 C. The commissioner may at any time after the filing of the original application,  
88.2 and before the expiration of the license, require further statements to enable the commissioner  
88.3 to determine whether the application should be granted or denied or whether a license should  
88.4 be modified or revoked.

88.5 D. An application for a source material license must be accompanied by the fee  
88.6 prescribed under Minnesota Statutes, section 144.1205.

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

88.8 **4731.0790 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.**

88.9 **Subpart 1. Expiration.**

88.10 A. A specific license issued under parts 4731.0700 to 4731.0840 expires at the  
88.11 end of the day on the expiration date stated in the license, unless the licensee has filed an  
88.12 application for renewal under part 4731.0795 not less than 30 days before the expiration  
88.13 date stated in the existing license.

88.14 B. If an application for renewal has been filed at least 30 days before the expiration  
88.15 date stated in the existing license, the existing license expires at the end of the day on which  
88.16 the commissioner makes a final determination to deny the renewal application or, if the  
88.17 determination states an expiration date, the expiration date stated in the determination.

88.18 *[For text of subps 2 to 5, see M.R.]*

88.19 **4731.0820 REPORTING REQUIREMENTS.**

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

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

88.22 A. A licensee must make reports required under subparts 1 and 2 by telephone to  
88.23 the commissioner according to part 4731.0200, subpart 5. To the extent that the information  
88.24 is available at the time of notification, the information provided in the report must include:

89.1 *[For text of subitems (1) to (5), see M.R.]*

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

89.3 **4731.2350 PROCEDURES FOR RECEIVING AND OPENING PACKAGES.**

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

89.5 Subp. 4. **Immediate notification.** A licensee must immediately notify the final delivery  
89.6 carrier and the commissioner, by telephone, when:

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

89.8 C. The telephone notification to the commissioner required under this subpart  
89.9 must be made according to part 4731.0200, subpart 5.

89.10 *[For text of subps 5 and 6, see M.R.]*

89.11 **4731.2600 REPORTS; THEFT OR LOSS OF LICENSED MATERIAL.**

89.12 Subpart 1. **Telephone reports.** A licensee must report to the commissioner by  
89.13 telephone, according to part 4731.0200, subpart 5, as follows:

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

89.18 B. within 30 days after an occurrence of any lost, stolen, or missing licensed  
89.19 material becomes known to the licensee, all licensed material in a quantity greater than ten  
89.20 times the quantity under part 4731.2800 that is still missing at the time of the report.

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

89.22 Subp. 3. [See repealer.]

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

90.1 **4731.2610 NOTIFICATION OF INCIDENTS.**

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

90.3 Subp. 4. **Reporting method.** Licensees must make the reports required under this  
90.4 part to the commissioner by telephone according to part 4731.0200, subpart 5.

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

90.6 **4731.2950 LOW-LEVEL RADIOACTIVE WASTE; TRANSFER AND DISPOSAL.**

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

90.8 Subp. 2. **Manifest.**

90.9 *[For text of items A to E, see M.R.]*

90.10 F. NRC Forms 540, 540A, 541, 541A, 542, and 542A, and the accompanying  
90.11 instructions, in hard copy, may be obtained from the Information and Records Management  
90.12 Branch, Office of the Chief Information Officer, U.S. Nuclear Regulatory Commission,  
90.13 Washington, DC 20555, telephone (301) 415-7232. The forms are available online at  
90.14 <http://www.nrc.gov/reading-rm/doc-collections/forms>.

90.15 *[For text of subps 3 to 14, see M.R.]*

90.16 **4731.3030 EXEMPTION; CERTAIN ITEMS CONTAINING RADIOACTIVE**  
90.17 **MATERIAL.**

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

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

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

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

91.5 (3) devices in subitems (1) and (2) authorized before December 31, 2014,  
91.6 for use under a general license, that were manufactured, tested, and labeled by the  
91.7 manufacturer in accordance with the specifications contained in a specific license issued  
91.8 by the commissioner, the NRC, or an agreement state.

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

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

91.11 **4731.3065 SPECIFIC LICENSES; APPLICATION.**

91.12 **Subpart 1. General requirements.**

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

91.14 B. An application must be signed by the applicant or licensee or a person duly  
91.15 authorized to act for and on behalf of the applicant or licensee.

91.16 C. The commissioner may at any time after the filing of the original application,  
91.17 and before the expiration of the license, require further statements to enable the commissioner  
91.18 to determine whether the application should be granted or denied or whether a license should  
91.19 be modified or revoked.

91.20 D. An application must be accompanied by the fee prescribed under Minnesota  
91.21 Statutes, section 144.1205.

91.22 E. An application for a license to receive and possess radioactive material that  
91.23 the commissioner has determined will significantly affect the quality of the environment  
91.24 must be filed at least nine months prior to commencement of construction of the plant or

92.1 facility in which the activity will be conducted and must be accompanied by any  
92.2 environmental report as required under Code of Federal Regulations, title 10, part 51, subpart  
92.3 A.

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

92.5 **4731.3075 TERMS AND CONDITIONS OF LICENSES.**

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

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

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

92.14 **4731.3085 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.**

92.15 Subpart 1. **Expiration.**

92.16 A. A specific license expires at the end of the day on the expiration date stated in  
92.17 the license, unless the licensee has filed an application for renewal under part 4731.3090  
92.18 not less than 30 days before the expiration date stated in the existing license.

92.19 B. If an application for renewal has been filed at least 30 days before the expiration  
92.20 date stated in the existing license, the existing license expires at the end of the day on which  
92.21 the commissioner makes a final determination to deny the renewal application or, if the  
92.22 determination states an expiration date, the expiration date stated in the determination.

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

93.1 **4731.3110 REPORTING REQUIREMENTS.**

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

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

93.4 A. A licensee must make reports required under subparts 1 and 2 by telephone to  
93.5 the commissioner according to part 4731.0200, subpart 5. To the extent that the information  
93.6 is available at the time of notification, the information provided in the report must include:

93.7 *[For text of subitems (1) to (5), see M.R.]*

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

93.9 **4731.3395 SPECIFIC LICENSE; RADIOACTIVE DRUGS FOR MEDICAL USE;**  
93.10 **MANUFACTURE, PREPARATION, OR TRANSFER.**

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

93.12 **Subp. 2. Pharmacy licensees.**

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

93.14 C. A licensee described in subpart 1, item B, subitem (3) or (4), may designate a  
93.15 pharmacist as an authorized nuclear pharmacist if the individual was a nuclear pharmacist  
93.16 preparing only radioactive drugs containing accelerator-produced radioactive material, and  
93.17 the individual practiced at a pharmacy at a government agency or federally recognized  
93.18 Indian Tribe before November 30, 2007, or at all other pharmacies before August 8, 2009,  
93.19 or an earlier date as noticed by the NRC.

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

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

94.1 (3) documentation that only accelerator-produced radioactive materials were  
94.2 used in the practice of nuclear pharmacy at a government agency or federally recognized  
94.3 Indian Tribe before November 30, 2007, or at all other pharmacies before August 8, 2009,  
94.4 or an earlier date as noticed by the NRC; and

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

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

94.7 **4731.4030 PERFORMANCE REQUIREMENTS; INDUSTRIAL RADIOGRAPHY**  
94.8 **EQUIPMENT.**

94.9 Subpart 1. **ANSI standard.**

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

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

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

94.19 Subp. 2. **Additional requirements.**

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

94.21 C. Radiographic exposure devices intended for use as Type B transport containers  
94.22 must meet the applicable requirements under parts 4731.0400 to 4731.0424.

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

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

95.1 **4731.4110 LABELING; PACKAGING; SECURITY.**

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

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

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

95.7 **4731.4140 RADIOGRAPHER TRAINING.**

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

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

95.11 D. receives copies of and instruction in parts 4731.0200, 4731.0280, and  
95.12 4731.0290; the applicable DOT regulations under parts 4731.0400 to 4731.0424; the  
95.13 applicable portions of parts 4731.1000 to 4731.2950; parts 4731.4000 to 4731.4360; the  
95.14 license under which the radiographer will perform industrial radiography; and the licensee's  
95.15 operating and emergency procedures;

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

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

95.19 A. receives copies of and instruction in parts 4731.0200, 4731.0280, and  
95.20 4731.0290; the applicable DOT regulations under parts 4731.0400 to 4731.0424; the  
95.21 applicable portions of parts 4731.1000 to 4731.2950; parts 4731.4000 to 4731.4360; the  
95.22 license under which the radiographer's assistant will perform industrial radiography; and  
95.23 the licensee's operating and emergency procedures;

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

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

**4731.4350 NOTIFICATIONS.**

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

Subp. 3. **Preparation and submission of notifications.** A licensee must make notifications required under subparts 1 and 2 by telephone to the commissioner according to part 4731.0200, subpart 5. To the extent the information is available at the time of notification, the information provided must include:

*[For text of items A to E, see M.R.]*

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

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

Subpart 1. **Labeling.**

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

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

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

**4731.7280 NOTIFICATION OF INCIDENTS AND LOST SOURCES;  
ABANDONMENT PROCEDURES.**

Subpart 1. **Notification; ruptured source.** A licensee must immediately notify the commissioner by telephone according to part 4731.0200, subpart 5, and subsequently, within 30 days, by confirmatory letter if the licensee knows or has reason to believe that a sealed source has been ruptured. The letter must:

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

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

97.2 Subp. 3. **Abandonment and sealing procedures.** If a sealed source becomes lodged  
97.3 in a well, and when it becomes apparent that efforts to recover the sealed source will not  
97.4 be successful, the licensee must:

97.5 A. notify the commissioner by telephone according to part 4731.0200, subpart 5,  
97.6 of the circumstances that resulted in the inability to retrieve the source;

97.7 *[For text of items B to F, see M.R.]*

97.8 *[For text of subp 4, see M.R.]*

97.9 **4731.8025 REQUIREMENTS FOR CRIMINAL HISTORY RECORDS CHECKS**  
97.10 **OF INDIVIDUALS GRANTED UNESCORTED ACCESS TO CATEGORY 1 OR**  
97.11 **CATEGORY 2 QUANTITIES OF RADIOACTIVE MATERIAL.**

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

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

97.14 A. For the purpose of complying with parts 4731.8010 to 4731.8040, licensees  
97.15 must submit to the U.S. Nuclear Regulatory Commission, Director, Division of Facilities  
97.16 and Security, 11545 Rockville Pike, ATTN: Criminal History Program/Mail Stop TWB-05  
97.17 B32M, Rockville, MD 20852-2738, one completed, legible standard fingerprint card (Form  
97.18 FD-258, ORIMDNRCOOOZ), electronic fingerprint scan or, where practicable, other  
97.19 fingerprint record for each individual requiring unescorted access to category 1 or category  
97.20 2 quantities of radioactive material. Copies of these forms may be obtained by writing the  
97.21 Office of the Chief Information Officer, U.S. Nuclear Regulatory Commission, Washington,  
97.22 DC 20555-0001, by calling (630) 829-9565, or by e-mail to FORMS.Resource@nrc.gov.  
97.23 Guidance on submitting electronic fingerprints can be found at  
97.24 <http://www.nrc.gov/site-help/e-submittals.html>.

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

98.1 **4731.8030 RELIEF FROM FINGERPRINTING, IDENTIFICATION, AND**  
98.2 **CRIMINAL HISTORY RECORDS CHECKS AND OTHER ELEMENTS OF**  
98.3 **BACKGROUND INVESTIGATIONS.**

98.4 Subpart 1. **Exemption to certain security checks.** Fingerprinting, and the identification  
98.5 and criminal history records checks required by section 149 of the Atomic Energy Act of  
98.6 1954, as amended, and other elements of the background investigation are not required for  
98.7 the following individuals prior to granting unescorted access to category 1 or category 2  
98.8 quantities of radioactive materials:

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

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

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

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

98.14 **4731.8100 ADDITIONAL REQUIREMENTS FOR TRANSFER OF CATEGORY**  
98.15 **1 AND CATEGORY 2 QUANTITIES OF RADIOACTIVE MATERIAL.**

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

98.19 A. Any licensee transferring category 1 quantities of radioactive material to a  
98.20 licensee of the commissioner, the NRC, or an agreement state, prior to conducting the  
98.21 transfer, must verify with the NRC's license verification system or the license-issuing  
98.22 authority that the transferee's license authorizes the receipt of the type, form, and quantity  
98.23 of radioactive material to be transferred and that the licensee is authorized to receive  
98.24 radioactive material at the location requested for delivery. If the verification is conducted  
98.25 by contacting the license-issuing authority, the transferor must document the verification.  
98.26 For transfers within the same organization, the licensee does not need to verify the transfer.

99.1 B. Any licensee transferring category 2 quantities of radioactive material to a  
99.2 licensee of the commissioner, the NRC, or an agreement state, prior to conducting the  
99.3 transfer, must verify with the NRC's license verification system or the license-issuing  
99.4 authority that the transferee's license authorizes the receipt of the type, form, and quantity  
99.5 of radioactive material to be transferred. If the verification is conducted by contacting the  
99.6 license-issuing authority, the transferor must document the verification. For transfers within  
99.7 the same organization, the licensee does not need to verify the transfer.

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

99.9 **4731.8115 ADVANCE NOTIFICATION OF SHIPMENT OF CATEGORY 1**  
99.10 **QUANTITIES OF RADIOACTIVE MATERIAL.**

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

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

99.13 A. The notification must be made to the commissioner and to the office of each  
99.14 appropriate governor or governor's designee. The contact information, including telephone  
99.15 numbers and mailing addresses, of governors and governors' designees, is available on the  
99.16 NRC Web site at <https://scp.nrc.gov/special/designee.pdf>. A list of the contact information  
99.17 is also available upon request from the Director, Division of Material Safety, State, Tribal,  
99.18 and Rulemaking Programs, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear  
99.19 Regulatory Commission, Washington, DC 20555. Notifications to the commissioner must  
99.20 be to the Radioactive Materials Unit, Minnesota Department of Health, 625 Robert Street  
99.21 N, P.O. Box 64975, St. Paul, MN 55164-0975, or e-mail at [health.ram@state.mn.us](mailto:health.ram@state.mn.us).

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

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

99.24 **Subp. 5. Cancellation notice.** Each licensee who cancels a shipment for which advance  
99.25 notification has been sent must send a cancellation notice to the commissioner and to the

100.1 governor of each state or to the governor's designee previously notified. The licensee must  
100.2 send the cancellation notice before the shipment would have commenced or as soon thereafter  
100.3 as possible. The licensee must state in the notice that it is a cancellation and identify the  
100.4 advance notification that is being canceled.

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

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

100.10 **REPEALER.** Minnesota Rules, parts 4731.0407; 4731.0421; 4731.0455; 4731.0600,  
100.11 subpart 3; and 4731.2600, subpart 3, are repealed.

July 29, 2019

**VIA EMAIL ONLY**

Nancy Breems  
Secretary of State, Elections Division  
180 State Office Building  
100 Rev Dr Martin Luther King Jr Blvd  
St. Paul, Minnesota 55155-1299  
[official.documents@state.mn.us](mailto:official.documents@state.mn.us)

**Re: *In the Matter of Possible Amendments to Rules Governing  
Radioactive Materials*  
OAH 21-9000-35988; Revisor R-4477**

Dear Ms. Breems:

Enclosed for filing is an electronic copy of the above-entitled adopted rules.

Please send the agency copy of the rules to:

Jacqueline Cavanagh  
445 Minnesota Street  
Saint Paul, MN 55101

If you have any questions regarding this matter, please contact Ian Lewenstein at (651) 361-7857, [ian.lewenstein@state.mn.us](mailto:ian.lewenstein@state.mn.us) or via facsimile at (651) 539-0310.

Sincerely,

  
LISA ARMSTRONG  
Legal Assistant

Enclosures

cc: Jacqueline Cavanagh (via email)  
Ian Lewenstein (via email)