Department of Health

Proposed Permanent Rules Governing Radiation Safety

4717.7000 VARIANCE REQUEST.

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

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

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

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

S. radioactive materials, parts 4731.0100 to 4731.8140.

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

4731.0100 DEFINITIONS.

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

Subp. 50a. **Criticality safety index or CSI.** "Criticality safety index" or "CSI" means the dimensionless number, rounded up to the next tenth, assigned to and placed on the label of a fissile material package, to designate the degree of control of accumulation of packages, overpacks, or freight containers containing fissile material during transportation. Determination of the criticality safety index is described in parts 4731.0410 and 4731.0411 and Code of Federal Regulations, title 10, section 71.59. The criticality safety index for an overpack, freight container, consignment, or conveyance containing fissile material packages is the arithmetic sum of the criticality safety indices of all the fissile material packages contained within the overpack, freight container, consignment, or conveyance.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Subp. 224. **Special form radioactive material.** "Special form radioactive material" 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, ~~and~~ 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~~ Tribal leadership, such as the chief, president, or ~~tribal~~ 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.]

B. The out-of-state licensee must:

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

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

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

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

4731.0400 SCOPE; ENFORCEMENT NOTICE.

Subpart 1. **Scope.** Parts 4731.0400 to ~~4731.0455~~ 4731.0424 establish requirements for the packaging, preparation for shipment, and transportation of licensed material.

Subp. 2. **Application of other law.** The packaging and transport of licensed material are subject to this chapter~~; Code of Federal Regulations, title 10, parts 21, 70, and 73;~~ and the regulations of other agencies, such as the NRC, DOT, and United States Postal Service, having jurisdiction over means of transport. The requirements of parts 4731.0400 to ~~4731.0455~~ 4731.0424 are in addition to, and not in substitution for, other requirements.

Subp. 3. **Applicability.**

~~A.~~ Parts 4731.0400 to ~~4731.0455~~ 4731.0424 apply to any licensee authorized by a specific or general license issued by the commissioner to receive, possess, use, or transfer licensed material, if the licensee delivers that material to a carrier for transport, transports the material outside the site of usage as specified in an NRC or agreement state license, or

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

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

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

A. Contamination means the presence of a radioactive substance on a surface in quantities in excess of 1 x 10^{-5} μCi/cm^2 (0.4 Bq/cm^2) for beta and gamma emitters and low-toxicity alpha emitters, or (1 x 10^{-6} μCi/cm^2) 0.04 Bq/$cm^2$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 ~~4731.0455~~ 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 ~~4731.0455~~ 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 ~~4731.0455~~ 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; ~~and~~

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

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

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

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

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

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

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

4731.0406 GENERAL LICENSE; NRC-APPROVED PACKAGE.

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

Subp. 2. **Approved quality assurance program.** The general license issued under subpart 1 applies only to a licensee who has a quality assurance program approved by the ~~NRC~~ commissioner as complying with ~~Code of Federal Regulations, title 10, part 71, subpart H~~ part 4731.0420.

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

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

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

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

C. ~~(3) submits~~ submit in writing to the NRC, before the licensee's first use of the package, the licensee's name and license number and the package identification number specified in the package approval. For the submittal to the NRC, the licensee must use an approved method listed in the Code of Federal Regulations, title 10, section 71.1(a), addressed to: ATTN: Document Control Desk, Director, Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards.

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

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

4731.0409 GENERAL LICENSE; FOREIGN-APPROVED PACKAGE.

Subpart 1. **License for foreign-approved package.** A general license is issued to any licensee of the commissioner to transport, or to deliver to a carrier for transport, licensed material in a package the design of which has been approved in a foreign national competent authority certificate that has been revalidated by the DOT as meeting the applicable requirements of Code of Federal Regulations, title 49, section ~~171.12~~ 171.23.

Subp. 2. **Approved quality assurance program.** Except as otherwise provided in parts 4731.0400 to ~~4731.0455~~ 4731.0424, the general license issued under subpart 1 applies

only to a licensee who has a quality assurance program approved by the ~~NRC~~ commissioner as complying with ~~Code of Federal Regulations, title 10, part 71, subpart H~~ part 4731.0420.

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

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

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

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

4731.0414 PRELIMINARY DETERMINATIONS.

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

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

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

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

4731.0415 ROUTINE DETERMINATIONS.

Before each shipment of licensed material, a licensee must ensure that the package with its contents satisfies the applicable requirements of the license and parts 4731.0400 to ~~4731.0455~~ 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 ~~4731.0455~~ 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

(3) any abnormal or unusual condition relevant to radiation safety;

F. date of the shipment;

G. for fissile packages and for Type B packages, any special controls exercised;

H. name and address of the transferee;

I. address to which the shipment was made; and

J. results of the determinations required by part 4731.0415 and by the conditions of the package approval.

Subp. 2. **Record availability.** The licensee must make available to the commissioner for inspection, upon reasonable notice, all records required by parts 4731.0400 to 4731.0424. Records are only valid if stamped, initialed, or signed and dated by authorized personnel, or otherwise authenticated.

Subp. 3. **Record of package quality.** The licensee must maintain sufficient written records to furnish evidence of the quality of packaging. The records to be maintained include results of the determinations required by Code of Federal Regulations, title 10, part 71.85; design, fabrication, and assembly records; results of reviews, inspections, tests, and audits; results of monitoring work performance and materials analyses; and results of maintenance,

modification, and repair activities. Inspection, test, and audit records must identify the inspector or data recorder, the type of observation, the results, the acceptability, and the action taken in connection with any deficiencies noted. These records must be retained for three years after the life of the packaging to which they apply.

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

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

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

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

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

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

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

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

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

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

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

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

A. The notification required under this part must:

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

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

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

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

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

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

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

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

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

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

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

Subp. 6. **Cancellation notice.**

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

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

4731.0420 QUALITY ASSURANCE REQUIREMENTS.

Subpart 1. **Program requirement.**

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

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

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

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

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

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

B. The quality assurance functions are:

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

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

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

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

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

cleanliness; and assurance that all prerequisites for the given activity have been satisfied. The licensee must take into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality and the need for verification of quality by inspection and test.

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

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

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

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

(4) the degree to which functional compliance can be demonstrated by inspection or test; and

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

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

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

A. A quality assurance program approval holder must submit a description of a proposed change to its commissioner-approved quality assurance program that will reduce commitments in the program description as approved by the commissioner. The quality

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4731.0422 A_1 AND A_2 VALUES FOR RADIONUCLIDES.

Subpart 1. [Repealed, 32 SR 831]

Subp. 1a. **A_1 and A_2 values.**

Element and atomic number and symbol of radionuclide	A_1 (TBq)	A_1 (Ci)[b]	A_2 (TBq)	A_2 (Ci)[b]
Actinium (89)				
Ac-225[a]	8.0×10^{-1}	2.2×10^{1}	6.0×10^{-3}	1.6×10^{-1}
Ac-227[a]	9.0×10^{-1}	2.4×10^{1}	9.0×10^{-5}	2.4×10^{-3}
Ac-228	6.0×10^{-1}	1.6×10^{1}	5.0×10^{-1}	1.4×10^{1}
Silver (47)				
Ag-105	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Ag-108m[a]	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Ag-110m[a]	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Ag-111	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Aluminum (13)				
Al-26	1.0×10^{-1}	2.7	1.0×10^{-1}	2.7
Americium (95)				
Am-241	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Am-242m[a]	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Am-243[a]	5.0	1.4×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Argon (18)				
Ar-37	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}

Ar-39	4.0×10^{1}	1.1×10^{3}	2.0×10^{1}	5.4×10^{2}
Ar-41	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Arsenic (33)				
As-72	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
As-73	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
As-74	1.0	2.7×10^{1}	9.0×10^{-1}	2.4×10^{1}
As-76	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
As-77	2.0×10^{1}	5.4×10^{2}	7.0×10^{-1}	1.9×10^{1}
Astatine (85)				
At-211[a]	2.0×10^{1}	5.4×10^{2}	5.0×10^{-1}	1.4×10^{1}
Gold (79)				
Au-193	7.0	1.9×10^{2}	2.0	5.4×10^{1}
Au-194	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Au-195	1.0×10^{1}	2.7×10^{2}	6.0	1.6×10^{2}
Au-198	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Au-199	1.0×10^{1}	2.7×10^{2}	6.0×10^{-1}	1.6×10^{1}
Barium (56)				
Ba-131[a]	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Ba-133	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Ba-133m	2.0×10^{1}	5.4×10^{2}	6.0×10^{-1}	1.6×10^{1}
Ba-140[a]	5.0×10^{-1}	1.4×10^{1}	3.0×10^{-1}	8.1
Beryllium (4)				
Be-7	2.0×10^{1}	5.4×10^{2}	2.0×10^{1}	5.4×10^{2}
Be-10	4.0×10^{1}	1.1×10^{3}	6.0×10^{-1}	1.6×10^{1}
Bismuth (83)				
Bi-205	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Bi-206	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1

Bi-207	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Bi-210	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Bi-210m[a]	6.0×10^{-1}	1.6×10^{1}	2.0×10^{-2}	5.4×10^{-1}
Bi-212[a]	7.0×10^{-1}	1.9×10^{1}	6.0×10^{-1}	1.6×10^{1}
Berkelium (97)				
Bk-247	8.0	2.2×10^{2}	8.0×10^{-4}	2.2×10^{-2}
Bk-249[a]	4.0×10^{1}	1.1×10^{3}	3.0×10^{-1}	8.1
Bromine (35)				
Br-76	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Br-77	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Br-82	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Carbon (6)				
C-11	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
C-14	4.0×10^{1}	1.1×10^{3}	3.0	8.1×10^{1}
Calcium (20)				
Ca-41	Unlimited	Unlimited	Unlimited	Unlimited
Ca-45	4.0×10^{1}	1.1×10^{3}	1.0	2.7×10^{1}
Ca-47[a]	3.0	8.1×10^{1}	3.0×10^{-1}	8.1
Cadmium (48)				
Cd-109	3.0×10^{1}	8.1×10^{2}	2.0	5.4×10^{1}
Cd-113m	4.0×10^{1}	1.1×10^{3}	5.0×10^{-1}	1.4×10^{1}
Cd-115[a]	3.0	8.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Cd-115m	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Cerium (58)				
Ce-139	7.0	1.9×10^{2}	2.0	5.4×10^{1}
Ce-141	2.0×10^{1}	5.4×10^{2}	6.0×10^{-1}	1.6×10^{1}
Ce-143	9.0×10^{-1}	2.4×10^{1}	6.0×10^{-1}	1.6×10^{1}

Ce-144[a]	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Californium (98)				
Cf-248	4.0×10^{1}	1.1×10^{3}	6.0×10^{-3}	1.6×10^{-1}
Cf-249	3.0	8.1×10^{1}	8.0×10^{-4}	2.2×10^{-2}
Cf-250	2.0×10^{1}	5.4×10^{2}	2.0×10^{-3}	5.4×10^{-2}
Cf-251	7.0	1.9×10^{2}	7.0×10^{-4}	1.9×10^{-2}
Cf-252[h]	~~5.0~~ 1.0 x $10^{-2\ -1}$	~~1.4~~ 2.7	3.0×10^{-3}	8.1×10^{-2}
Cf-253[a]	4.0×10^{1}	1.1×10^{3}	4.0×10^{-2}	1.1
Cf-254	1.0×10^{-3}	2.7×10^{-2}	1.0×10^{-3}	2.7×10^{-2}
Chlorine (17)				
Cl-36	1.0×10^{1}	2.7×10^{2}	6.0×10^{-1}	1.6×10^{1}
Cl-38	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Curium (96)				
Cm-240	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
Cm-241	2.0	5.4×10^{1}	1.0	2.7×10^{1}
Cm-242	4.0×10^{1}	1.1×10^{3}	1.0×10^{-2}	2.7×10^{-1}
Cm-243	9.0	2.4×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Cm-244	2.0×10^{1}	5.4×10^{2}	2.0×10^{-3}	5.4×10^{-2}
Cm-245	9.0	2.4×10^{2}	9.0×10^{-4}	2.4×10^{-2}
Cm-246	9.0	2.4×10^{2}	9.0×10^{-4}	2.4×10^{-2}
Cm-247[a]	3.0	8.1×10^{1}	1.0×10^{-3}	2.7×10^{-2}
Cm-248	2.0×10^{-2}	5.4×10^{-1}	3.0×10^{-4}	8.1×10^{-3}
Cobalt (27)				
Co-55	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Co-56	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Co-57	1.0×10^{1}	2.7×10^{2}	1.0×10^{1}	2.7×10^{2}
Co-58	1.0	2.7×10^{1}	1.0	2.7×10^{1}

Co-58m	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Co-60	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Chromium (24)				
Cr-51	3.0×10^{1}	8.1×10^{2}	3.0×10^{1}	8.1×10^{2}
Cesium (55)				
Cs-129	4.0	1.1×10^{2}	4.0	1.1×10^{2}
Cs-131	3.0×10^{1}	8.1×10^{2}	3.0×10^{1}	8.1×10^{2}
Cs-132	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Cs-134	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Cs-134m	4.0×10^{1}	1.1×10^{3}	6.0×10^{-1}	1.6×10^{1}
Cs-135	4.0×10^{1}	1.1×10^{3}	1.0	2.7×10^{1}
Cs-136	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Cs-137[a]	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Copper (29)				
Cu-64	6.0	1.6×10^{2}	1.0	2.7×10^{1}
Cu-67	1.0×10^{1}	2.7×10^{2}	7.0×10^{-1}	1.9×10^{1}
Dysprosium (66)				
Dy-159	2.0×10^{1}	5.4×10^{2}	2.0×10^{1}	5.4×10^{2}
Dy-165	9.0×10^{-1}	2.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Dy-166[a]	9.0×10^{-1}	2.4×10^{1}	3.0×10^{-1}	8.1
Erbium (68)				
Er-169	4.0×10^{1}	1.1×10^{3}	1.0	2.7×10^{1}
Er-171	8.0×10^{-1}	2.2×10^{1}	5.0×10^{-1}	1.4×10^{1}
Europium (63)				
Eu-147	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Eu-148	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Eu-149	2.0×10^{1}	5.4×10^{2}	2.0×10^{1}	5.4×10^{2}

Eu-150 (short-lived)	2.0	5.4×10^{1}	7.0×10^{-1}	1.9×10^{1}
Eu-150 (long-lived)	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Eu-152	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Eu-152m	8.0×10^{-1}	2.2×10^{1}	8.0×10^{-1}	2.2×10^{1}
Eu-154	9.0×10^{-1}	2.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Eu-155	2.0×10^{1}	5.4×10^{2}	3.0	8.1×10^{1}
Eu-156	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Fluorine (9)				
F-18	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Iron (26)				
Fe-52[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Fe-55	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Fe-59	9.0×10^{-1}	2.4×10^{1}	9.0×10^{-1}	2.4×10^{1}
Fe-60[a]	4.0×10^{1}	1.1×10^{3}	2.0×10^{-1}	5.4
Gallium (31)				
Ga-67	7.0	1.9×10^{2}	3.0	8.1×10^{1}
Ga-68	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Ga-72	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Gadolinium (64)				
Gd-146[a]	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Gd-148	2.0×10^{1}	5.4×10^{2}	2.0×10^{-3}	5.4×10^{-2}
Gd-153	1.0×10^{1}	2.7×10^{2}	9.0	2.4×10^{2}
Gd-159	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}
Germanium (32)				
Ge-68[a]	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Ge-71	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Ge-77	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1

Hafnium (72)				
Hf-172[a]	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Hf-175	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Hf-181	2.0	5.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Hf-182	Unlimited	Unlimited	Unlimited	Unlimited
Mercury (80)				
Hg-194[a]	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Hg-195m[a]	3.0	8.1×10^{1}	7.0×10^{-1}	1.9×10^{1}
Hg-197	2.0×10^{1}	5.4×10^{2}	1.0×10^{1}	2.7×10^{2}
Hg-197m	1.0×10^{1}	2.7×10^{2}	4.0×10^{-1}	1.1×10^{1}
Hg-203	5.0	1.4×10^{2}	1.0	2.7×10^{1}
Holmium (67)				
Ho-166	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Ho-166m	6.0×10^{-1}	1.6×10^{1}	5.0×10^{-1}	1.4×10^{1}
Iodine (53)				
I-123	6.0	1.6×10^{2}	3.0	8.1×10^{1}
I-124	1.0	2.7×10^{1}	1.0	2.7×10^{1}
I-125	2.0×10^{1}	5.4×10^{2}	3.0	8.1×10^{1}
I-126	2.0	5.4×10^{1}	1.0	2.7×10^{1}
I-129	Unlimited	Unlimited	Unlimited	Unlimited
I-131	3.0	8.1×10^{1}	7.0×10^{-1}	1.9×10^{1}
I-132	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
I-133	7.0×10^{-1}	1.9×10^{1}	6.0×10^{-1}	1.6×10^{1}
I-134	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
I-135[a]	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Indium (49)				
In-111	3.0	8.1×10^{1}	3.0	8.1×10^{1}

In-113m	4.0	1.1×10^{2}	2.0	5.4×10^{1}
In-114m[a]	1.0×10^{1}	2.7×10^{2}	5.0×10^{-1}	1.4×10^{1}
In-115m	7.0	1.9×10^{2}	1.0	2.7×10^{1}
Iridium (77)				
Ir-189[a]	1.0×10^{1}	2.7×10^{2}	1.0×10^{1}	2.7×10^{2}
Ir-190	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Ir-192[c]	1.0[c]	2.7×10^{1}[c]	6.0×10^{-1}	1.6×10^{1}
Ir-194	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Potassium (19)				
K-40	9.0×10^{-1}	2.4×10^{1}	9.0×10^{-1}	2.4×10^{1}
K-42	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
K-43	7.0×10^{-1}	1.9×10^{1}	6.0×10^{-1}	1.6×10^{1}
Krypton (36)				
Kr-79	4.0	1.1×10^{2}	2.0	5.4×10^{1}
Kr-81	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Kr-85	1.0×10^{1}	2.7×10^{2}	1.0×10^{1}	2.7×10^{2}
Kr-85m	8.0	2.2×10^{2}	3.0	8.1×10^{1}
Kr-87	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Lanthanum (57)				
La-137	3.0×10^{1}	8.1×10^{2}	6.0	1.6×10^{2}
La-140	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Lutetium (71)				
Lu-172	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Lu-173	8.0	2.2×10^{2}	8.0	2.2×10^{2}
Lu-174	9.0	2.4×10^{2}	9.0	2.4×10^{2}
Lu-174m	2.0×10^{1}	5.4×10^{2}	1.0×10^{1}	2.7×10^{2}
Lu-177	3.0×10^{1}	8.1×10^{2}	7.0×10^{-1}	1.9×10^{1}

Magnesium (12)				
Mg-28[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Manganese (25)				
Mn-52	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Mn-53	Unlimited	Unlimited	Unlimited	Unlimited
Mn-54	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Mn-56	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Molybdenum (42)				
Mo-93	4.0×10^{1}	1.1×10^{3}	2.0×10^{1}	5.4×10^{2}
Mo-99[a,i h]	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Nitrogen (7)				
N-13	9.0×10^{-1}	2.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Sodium (11)				
Na-22	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Na-24	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Niobium (41)				
Nb-93m	4.0×10^{1}	1.1×10^{3}	3.0×10^{1}	8.1×10^{2}
Nb-94	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Nb-95	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Nb-97	9.0×10^{-1}	2.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Neodymium (60)				
Nd-147	6.0	1.6×10^{2}	6.0×10^{-1}	1.6×10^{1}
Nd-149	6.0×10^{-1}	1.6×10^{1}	5.0×10^{-1}	1.4×10^{1}
Nickel (28)				
Ni-59	Unlimited	Unlimited	Unlimited	Unlimited
Ni-63	4.0×10^{1}	1.1×10^{3}	3.0×10^{1}	8.1×10^{2}

Ni-65	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Neptunium (93)				
Np-235	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Np-236 (short-lived)	2.0×10^{1}	5.4×10^{2}	2.0	5.4×10^{1}
Np-236 (long-lived)	9.0×10^{0}	2.4×10^{2}	2.0×10^{-2}	5.4×10^{-1}
Np-237	2.0×10^{1}	5.4×10^{2}	2.0×10^{-3}	5.4×10^{-2}
Np-239	7.0	1.9×10^{2}	4.0×10^{-1}	1.1×10^{1}
Osmium (76)				
Os-185	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Os-191	1.0×10^{1}	2.7×10^{2}	2.0	5.4×10^{1}
Os-191m	4.0×10^{1}	1.1×10^{3}	3.0×10^{1}	8.1×10^{2}
Os-193	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Os-194[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Phosphorus (15)				
P-32	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
P-33	4.0×10^{1}	1.1×10^{3}	1.0	2.7×10^{1}
Protactinium (91)				
Pa-230[a]	2.0	5.4×10^{1}	7.0×10^{-2}	1.9
Pa-231	4.0	1.1×10^{2}	4.0×10^{-4}	1.1×10^{-2}
Pa-233	5.0	1.4×10^{2}	7.0×10^{-1}	1.9×10^{1}
Lead (82)				
Pb-201	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Pb-202	4.0×10^{1}	1.1×10^{3}	2.0×10^{1}	5.4×10^{2}
Pb-203	4.0	1.1×10^{2}	3.0	8.1×10^{1}
Pb-205	Unlimited	Unlimited	Unlimited	Unlimited
Pb-210[a]	1.0	2.7×10^{1}	5.0×10^{-2}	1.4
Pb-212[a]	7.0×10^{-1}	1.9×10^{1}	2.0×10^{-1}	5.4

Palladium (46)				
Pd-103[a]	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Pd-107	Unlimited	Unlimited	Unlimited	Unlimited
Pd-109	2.0	5.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Promethium (61)				
Pm-143	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Pm-144	7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}
Pm-145	3.0×10^{1}	8.1×10^{2}	1.0×10^{1}	2.7×10^{2}
Pm-147	4.0×10^{1}	1.1×10^{3}	2.0	5.4×10^{1}
Pm-148m[a]	8.0×10^{-1}	2.2×10^{1}	7.0×10^{-1}	1.9×10^{1}
Pm-149	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Pm-151	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Polonium (84)				
Po-210	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
Praseodymium (59)				
Pr-142	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Pr-143	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}
Platinum (78)				
Pt-188[a]	1.0	2.7×10^{1}	8.0×10^{-1}	2.2×10^{1}
Pt-191	4.0	1.1×10^{2}	3.0	8.1×10^{1}
Pt-193	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Pt-193m	4.0×10^{1}	1.1×10^{3}	5.0×10^{-1}	1.4×10^{1}
Pt-195m	1.0×10^{1}	2.7×10^{2}	5.0×10^{-1}	1.4×10^{1}
Pt-197	2.0×10^{1}	5.4×10^{2}	6.0×10^{-1}	1.6×10^{1}
Pt-197m	1.0×10^{1}	2.7×10^{2}	6.0×10^{-1}	1.6×10^{1}
Plutonium (94)				
Pu-236	3.0×10^{1}	8.1×10^{2}	3.0×10^{-3}	8.1×10^{-2}

Pu-237	2.0×10^{1}	5.4×10^{2}	2.0×10^{1}	5.4×10^{2}
Pu-238	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Pu-239	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Pu-240	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Pu-241[a]	4.0×10^{1}	1.1×10^{3}	6.0×10^{-2}	1.6
Pu-242	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Pu-244[a]	4.0×10^{-1}	1.1×10^{1}	1.0×10^{-3}	2.7×10^{-2}
Radium (88)				
Ra-223[a]	4.0×10^{-1}	1.1×10^{1}	7.0×10^{-3}	1.9×10^{-1}
Ra-224[a]	4.0×10^{-1}	1.1×10^{1}	2.0×10^{-2}	5.4×10^{-1}
Ra-225[a]	2.0×10^{-1}	5.4	4.0×10^{-3}	1.1×10^{-1}
Ra-226[a]	2.0×10^{-1}	5.4	3.0×10^{-3}	8.1×10^{-2}
Ra-228[a]	6.0×10^{-1}	1.6×10^{1}	2.0×10^{-2}	5.4×10^{-1}
Rubidium (37)				
Rb-81	2.0	5.4×10^{1}	8.0×10^{-1}	2.2×10^{1}
Rb-83[a]	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Rb-84	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Rb-86	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Rb-87	Unlimited	Unlimited	Unlimited	Unlimited
Rb (nat)	Unlimited	Unlimited	Unlimited	Unlimited
Rhenium (75)				
Re-184	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Re-184m	3.0	8.1×10^{1}	1.0	2.7×10^{1}
Re-186	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
Re-187	Unlimited	Unlimited	Unlimited	Unlimited
Re-188	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Re-189[a]	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}

Re (nat)	Unlimited	Unlimited	Unlimited	Unlimited
Rhodium (45)				
Rh-99	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Rh-101	4.0	1.1×10^{2}	3.0	8.1×10^{1}
Rh-102	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Rh-102m	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Rh-103m	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Rh-105	1.0×10^{1}	2.7×10^{2}	8.0×10^{-1}	2.2×10^{1}
Radon (86)				
Rn-222[a]	3.0×10^{-1}	8.1	4.0×10^{-3}	1.1×10^{-1}
Ruthenium (44)				
Ru-97	5.0	1.4×10^{2}	5.0	1.4×10^{2}
Ru-103[a]	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Ru-105	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Ru-106[a]	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Sulphur (16)				
S-35	4.0×10^{1}	1.1×10^{3}	3.0	8.1×10^{1}
Antimony (51)				
Sb-122	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Sb-124	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Sb-125	2.0	5.4×10^{1}	1.0	2.7×10^{1}
Sb-126	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Scandium (21)				
Sc-44	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Sc-46	5.0×10^{-1}	1.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Sc-47	1.0×10^{1}	2.7×10^{2}	7.0×10^{-1}	1.9×10^{1}
Sc-48	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1

Selenium (34)				
Se-75	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Se-79	4.0×10^{1}	1.1×10^{3}	2.0	5.4×10^{1}
Silicon (14)				
Si-31	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Si-32	4.0×10^{1}	1.1×10^{3}	5.0×10^{-1}	1.4×10^{1}
Samarium (62)				
Sm-145	1.0×10^{1}	2.7×10^{2}	1.0×10^{1}	2.7×10^{2}
Sm-147	Unlimited	Unlimited	Unlimited	Unlimited
Sm-151	4.0×10^{1}	1.1×10^{3}	1.0×10^{1}	2.7×10^{2}
Sm-153	9.0	2.4×10^{2}	6.0×10^{-1}	1.6×10^{1}
Tin (50)				
Sn-113[a]	4.0	1.1×10^{2}	2.0	5.4×10^{1}
Sn-117m	7.0	1.9×10^{2}	4.0×10^{-1}	1.1×10^{1}
Sn-119m	4.0×10^{1}	1.1×10^{3}	3.0×10^{1}	8.1×10^{2}
Sn-121m[a]	4.0×10^{1}	1.1×10^{3}	9.0×10^{-1}	2.4×10^{1}
Sn-123	8.0×10^{-1}	2.2×10^{1}	6.0×10^{-1}	1.6×10^{1}
Sn-125	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Sn-126[a]	6.0×10^{-1}	1.6×10^{1}	4.0×10^{-1}	1.1×10^{1}
Strontium (38)				
Sr-82[a]	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Sr-85	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Sr-85m	5.0	1.4×10^{2}	5.0	1.4×10^{2}
Sr-87m	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Sr-89	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Sr-90[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1

Sr-91[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Sr-92[a]	1.0	2.7×10^{1}	3.0×10^{-1}	8.1
Tritium (1)				
T (H-3)	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Tantalum (73)				
Ta-178 (long-lived)	1.0	2.7×10^{1}	8.0×10^{-1}	2.2×10^{1}
Ta-179	3.0×10^{1}	8.1×10^{2}	3.0×10^{1}	8.1×10^{2}
Ta-182	9.0×10^{-1}	2.4×10^{1}	5.0×10^{-1}	1.4×10^{1}
Terbium (65)				
Tb-157	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Tb-158	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Tb-160	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}
Technetium (43)				
Tc-95m[a]	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Tc-96	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Tc-96m[a]	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Tc-97	Unlimited	Unlimited	Unlimited	Unlimited
Tc-97m	4.0×10^{1}	1.1×10^{3}	1.0	2.7×10^{1}
Tc-98	8.0×10^{-1}	2.2×10^{1}	7.0×10^{-1}	1.9×10^{1}
Tc-99	4.0×10^{1}	1.1×10^{3}	9.0×10^{-1}	2.4×10^{1}
Tc-99m	1.0×10^{1}	2.7×10^{2}	4.0	1.1×10^{2}
Tellurium (52)				
Te-121	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Te-121m	5.0	1.4×10^{2}	3.0	8.1×10^{1}
Te-123m	8.0	2.2×10^{2}	1.0	2.7×10^{1}
Te-125m	2.0×10^{1}	5.4×10^{2}	9.0×10^{-1}	2.4×10^{1}
Te-127	2.0×10^{1}	5.4×10^{2}	7.0×10^{-1}	1.9×10^{1}

Te-127m[a]	2.0×10^{1}	5.4×10^{2}	5.0×10^{-1}	1.4×10^{1}
Te-129	7.0×10^{-1}	1.9×10^{1}	6.0×10^{-1}	1.6×10^{1}
Te-129m[a]	8.0×10^{-1}	2.2×10^{1}	4.0×10^{-1}	1.1×10^{1}
Te-131m[a]	7.0×10^{-1}	1.9×10^{1}	5.0×10^{-1}	1.4×10^{1}
Te-132[a]	5.0×10^{-1}	1.4×10^{1}	4.0×10^{-1}	1.1×10^{1}
Thorium (90)				
Th-227	1.0×10^{1}	2.7×10^{2}	5.0×10^{-3}	1.4×10^{-1}
Th-228[a]	5.0×10^{-1}	1.4×10^{1}	1.0×10^{-3}	2.7×10^{-2}
Th-229	5.0	1.4×10^{2}	5.0×10^{-4}	1.4×10^{-2}
Th-230	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
Th-231	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
Th-232	Unlimited	Unlimited	Unlimited	Unlimited
Th-234[a]	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Th (nat)	Unlimited	Unlimited	Unlimited	Unlimited
Titanium (22)				
Ti-44[a]	5.0×10^{-1}	1.4×10^{1}	4.0×10^{-1}	1.1×10^{1}
Thallium (81)				
Tl-200	9.0×10^{-1}	2.4×10^{1}	9.0×10^{-1}	2.4×10^{1}
Tl-201	1.0×10^{1}	2.7×10^{2}	4.0	1.1×10^{2}
Tl-202	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Tl-204	1.0×10^{1}	2.7×10^{2}	7.0×10^{-1}	1.9×10^{1}
Thulium (69)				
Tm-167	7.0	1.9×10^{2}	8.0×10^{-1}	2.2×10^{1}
Tm-170	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}
Tm-171	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}

Uranium (92)				
U-230 (fast lung absorption)[a,d]	4.0×10^{1}	1.1×10^{3}	1.0×10^{-1}	2.7
U-230 (medium lung absorption)[a,e]	4.0×10^{1}	1.1×10^{3}	4.0×10^{-3}	1.1×10^{-1}
U-230 (slow lung absorption)[a,f]	3.0×10^{1}	8.1×10^{2}	3.0×10^{-3}	8.1×10^{-2}
U-232 (fast lung absorption)[d]	4.0×10^{1}	1.1×10^{3}	1.0×10^{-2}	2.7×10^{-1}
U-232 (medium lung absorption)[e]	4.0×10^{1}	1.1×10^{3}	7.0×10^{-3}	1.9×10^{-1}
U-232 (slow lung absorption)[f]	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}
U-233 (fast lung absorption)[d]	4.0×10^{1}	1.1×10^{3}	9.0×10^{-2}	2.4
U-233 (medium lung absorption)[e]	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
U-233 (slow lung absorption)[f]	4.0×10^{1}	1.1×10^{3}	6.0×10^{-3}	1.6×10^{-1}
U-234 (fast lung absorption)[d]	4.0×10^{1}	1.1×10^{3}	9.0×10^{-2}	2.4
U-234 (medium lung absorption)[e]	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
U-234 (slow lung absorption)[f]	4.0×10^{1}	1.1×10^{3}	6.0×10^{-3}	1.6×10^{-1}
U-235 (all lung absorption types)[a,d,e,f]	Unlimited	Unlimited	Unlimited	Unlimited
U-236 (fast lung absorption)[d]	Unlimited	Unlimited	Unlimited	Unlimited
U-236 (medium lung absorption)[e]	4.0×10^{1}	1.1×10^{3}	2.0×10^{-2}	5.4×10^{-1}
U-236 (slow lung absorption)[f]	4.0×10^{1}	1.1×10^{3}	6.0×10^{-3}	1.6×10^{-1}

U-238 (all lung absorption types)[d,e,f]	Unlimited	Unlimited	Unlimited	Unlimited
U (nat)	Unlimited	Unlimited	Unlimited	Unlimited
U (enriched to 20% or less)[g]	Unlimited	Unlimited	Unlimited	Unlimited
U (dep)	Unlimited	Unlimited	Unlimited	Unlimited
Vanadium (23)				
V-48	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
V-49	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Tungsten (74)				
W-178[a]	9.0	2.4×10^{2}	5.0	1.4×10^{2}
W-181	3.0×10^{1}	8.1×10^{2}	3.0×10^{1}	8.1×10^{2}
W-185	4.0×10^{1}	1.1×10^{3}	8.0×10^{-1}	2.2×10^{1}
W-187	2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}
W-188[a]	4.0×10^{-1}	1.1×10^{1}	3.0×10^{-1}	8.1
Xenon (54)				
Xe-122[a]	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Xe-123	2.0	5.4×10^{1}	7.0×10^{-1}	1.9×10^{1}
Xe-127	4.0	1.1×10^{2}	2.0	5.4×10^{1}
Xe-131m	4.0×10^{1}	1.1×10^{3}	4.0×10^{1}	1.1×10^{3}
Xe-133	2.0×10^{1}	5.4×10^{2}	1.0×10^{1}	2.7×10^{2}
Xe-135	3.0	8.1×10^{1}	2.0	5.4×10^{1}
Yttrium (39)				
Y-87[a]	1.0	2.7×10^{1}	1.0	2.7×10^{1}
Y-88	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}
Y-90	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Y-91	6.0×10^{-1}	1.6×10^{1}	6.0×10^{-1}	1.6×10^{1}
Y-91m	2.0	5.4×10^{1}	2.0	5.4×10^{1}

Y-92	2.0×10^{-1}	5.4	2.0×10^{-1}	5.4
Y-93	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1
Ytterbium (70)				
Yb-169	4.0	1.1×10^{2}	1.0	2.7×10^{1}
Yb-175	3.0×10^{1}	8.1×10^{2}	9.0×10^{-1}	2.4×10^{1}
Zinc (30)				
Zn-65	2.0	5.4×10^{1}	2.0	5.4×10^{1}
Zn-69	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}
Zn-69m[a]	3.0	8.1×10^{1}	6.0×10^{-1}	1.6×10^{1}
Zirconium (40)				
Zr-88	3.0	8.1×10^{1}	3.0	8.1×10^{1}
Zr-93	Unlimited	Unlimited	Unlimited	Unlimited
Zr-95[a]	2.0	5.4×10^{1}	8.0×10^{-1}	2.2×10^{1}
Zr-97[a]	4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}

[a] A_1 and A_2 values include contributions from daughter nuclides with half-lives less than ten days~~.~~ as listed in the following:

Mg-28	Al-28
Ca-47	Sc-47
Ti-44	Sc-44
Fe-52	Mn-52m
Fe-60	Co-60m
Zn-69m	Zn-69
Ge-68	Ga-68
Rb-83	Kr-83m
Sr-82	Rb-82
Sr-90	Y-90
Sr-91	Y-91m

Sr-92	Y-92
Y-87	Sr-87m
Zr-95	Nb-95m
Zr-97	Nb-97m, Nb-97
Mo-99	Tc-99m
Tc-95m	Tc-95
Tc-96m	Tc-96
Ru-103	Rh-103m
Ru-106	Rh-106
Pd-103	Rh-103m
Ag-108m	Ag-108
Ag-110m	Ag-110
Cd-115	In-115m
In-114m	In-114
Sn-113	In-113m
Sn-121m	Sn-121
Sn-126	Sb-126m
Te-127m	Te-127
Te-129m	Te-129
Te-131m	Te-131
Te-132	I-132
I-135	Xe-135m
Xe-122	I-122
Cs-137	Ba-137m
Ba-131	Cs-131
Ba-140	La-140
Ce-144	Pr-144m, Pr-144
Pm-148M	Pm-148
Gd-146	Eu-146

Dy-166	Ho-166
Hf-172	Lu-172
W-178	Ta-178
W-188	Re-188
Re-189	Os-189m
Os-194	Ir-194
Ir-189	Os-189m
Pt-188	Ir-188
Hg-194	Au-194
Hg-195m	Hg-195
Pb-210	Bi-210
Pb-212	Bi-212, Tl-208, Po-212
Bi-210m	Tl-206
Bi-212	Tl-208, Po-212
At-211	Po-211
Rn-222	Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Po-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Ra-225	Ac-225, Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ra-226	Rn-222, Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-228	Ac-228
Ac-225	Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ac-227	Fr-223
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Th-234	Pa-234m, Pa-234

Pa-230	Ac-226, Th-226, Fr-222, Ra-222, Rn-218, Po-214
U-230	Th-226, Ra-222, Rn-218, Po-214
U-235	Th-231
Pu-241	U-237
Pu-244	U-240, Np-240m
Am-242m	Am-242, Np-238
Am-243	Np-239
Cm-247	Pu-243
Bk-249	Am-245
Cf-253	Cm-249

[b]The values of A_1 and A_2 in curies (Ci) are approximate and for information only; the regulatory standard units are Terabecquerels (TBq). See part 4731.0423, subpart 1 - Determination of A_1 and A_2.

[c]The ~~quantity~~ activity of Ir-192 in special form may be determined from a measurement of the rate of decay or a measurement of the radiation level at a prescribed distance from the source.

[d]These values apply only to compounds of uranium that take the chemical form of UF_6, UO_2F_2, and $UO_2(NO_3)_2$ in both normal and accident conditions of transport.

[e]These values apply only to compounds of uranium that take the chemical form of UO_3, UF_4, and UCl_4 and hexavalent compounds in both normal and accident conditions of transport.

[f]These values apply to all compounds of uranium other than those specified in notes d and e.

[g]These values apply to unirradiated uranium only.

~~[h]A_1 = 0.1 TBq (2.7 Ci) and A_2 = 0.001 TBq (0.027 Ci) for Cf-252 for domestic use.~~

$\underline{\text{i h}}\underline{\_}A_2$ = 0.74 TBq (20 Ci) for Mo-99 for domestic use.

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

Element and Atomic Number and Symbol of Radionuclide	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Actinium (89)		
Ac-225	2.1×10^{3}	5.8×10^{4}
Ac-227	2.7	7.2×10^{1}
Ac-228	8.4×10^{4}	2.2×10^{6}
Silver (47)		
Ag-105	1.1×10^{3}	3.0×10^{4}
Ag-108m	9.7×10^{-1}	2.6×10^{1}
Ag-110m	1.8×10^{2}	4.7×10^{3}
Ag-111	5.8×10^{3}	1.6×10^{5}
Aluminum (13)		
Al-26	7.0×10^{-4}	1.9×10^{-2}
Americium (95)		
Am-241	1.3×10^{-1}	3.4
Am-242m	3.6×10^{-1}	1.0×10^{1}
Am-243	7.4×10^{-3}	2.0×10^{-1}
Argon (18)		
Ar-37	3.7×10^{3}	9.9×10^{4}
Ar-39	1.3	3.4×10^{1}
Ar-41	1.5×10^{6}	4.2×10^{7}
Ar-42	9.6	2.6×10^{2}

Arsenic (33)		
As-72	6.2×10^{4}	1.7×10^{6}
As-73	8.2×10^{2}	2.2×10^{4}
As-74	3.7×10^{3}	9.9×10^{4}
As-76	5.8×10^{4}	1.6×10^{6}
As-77	3.9×10^{4}	1.0×10^{6}
Astatine (85)		
At-211	7.6×10^{4}	2.1×10^{6}
Gold (79)		
Au-193	3.4×10^{4}	9.2×10^{5}
Au-194	1.5×10^{4}	4.1×10^{5}
Au-195	1.4×10^{2}	3.7×10^{3}
Au-196	4.0×10^{3}	1.1×10^{5}
Au-198	9.0×10^{3}	2.4×10^{5}
Au-199	7.7×10^{3}	2.1×10^{5}
Barium (56)		
Ba-131	3.1×10^{3}	8.4×10^{4}
Ba-133m	2.2×10^{4}	6.1×10^{5}
Ba-133	9.4	2.6×10^{2}
Ba-140	2.7×10^{3}	7.3×10^{4}
Beryllium (4)		
Be-7	1.3×10^{4}	3.5×10^{5}
Be-10	8.3×10^{-4}	2.2×10^{-2}
Bismuth (83)		
Bi-205	1.5×10^{3}	4.2×10^{4}
Bi-206	3.8×10^{3}	1.0×10^{5}
Bi-207	1.9	5.2×10^{1}

Bi-210m	2.1×10^{-5}	5.7×10^{-4}
Bi-210	4.6×10^{3}	1.2×10^{5}
Bi-212	5.4×10^{5}	1.5×10^{7}
Berkelium (97)		
Bk-247	3.8×10^{-2}	1.0
Bk-249	6.1×10^{1}	1.6×10^{3}
Bromine (35)		
Br-76	9.4×10^{4}	2.5×10^{6}
Br-77	2.6×10^{4}	7.1×10^{5}
Br-82	4.0×10^{4}	1.1×10^{6}
Carbon (6)		
C-11	3.1×10^{7}	8.4×10^{8}
C-14	1.6×10^{-1}	4.5
Calcium (20)		
Ca-41	3.1×10^{-3}	8.5×10^{-2}
Ca-45	6.6×10^{2}	1.8×10^{4}
Ca-47	2.3×10^{4}	6.1×10^{5}
Cadmium (48)		
Cd-109	9.6×10^{1}	2.6×10^{3}
Cd-113m	8.3	2.2×10^{2}
Cd-115m	9.4×10^{2}	2.5×10^{4}
Cd-115	1.9×10^{4}	5.1×10^{5}
Cerium (58)		
Ce-139	2.5×10^{2}	6.8×10^{3}
Ce-141	1.1×10^{3}	2.8×10^{4}
Ce-143	2.5×10^{4}	6.6×10^{5}
Ce-144	1.2×10^{2}	3.2×10^{3}

Californium (98)		
Cf-248	5.8×10^{1}	1.6×10^{3}
Cf-249	1.5×10^{-1}	4.1
Cf-250	4.0	1.1×10^{2}
Cf-251	5.9×10^{-2}	1.6
Cf-252	2.0×10^{1}	5.4×10^{2}
Cf-253	1.1×10^{3}	2.9×10^{4}
Cf-254	3.1×10^{2}	8.5×10^{3}
Chlorine (17)		
Cl-36	1.2×10^{-3}	3.3×10^{-2}
Cl-38	4.9×10^{6}	1.3×10^{8}
Curium (96)		
Cm-240	7.5×10^{2}	2.0×10^{4}
Cm-241	6.1×10^{2}	1.7×10^{4}
Cm-242	1.2×10^{2}	3.3×10^{3}
Cm-243	1.9×10^{-3}	5.2×10^{1}
Cm-244	3.0	8.1×10^{1}
Cm-245	6.4×10^{-3}	1.7×10^{-1}
Cm-246	1.1×10^{-2}	3.1×10^{-1}
Cm-247	3.4×10^{-6}	9.3×10^{-5}
Cm-248	1.6×10^{-4}	4.2×10^{-3}
Cobalt (27)		
Co-55	1.1×10^{5}	3.1×10^{6}
Co-56	1.1×10^{3}	3.0×10^{4}
Co-57	3.1×10^{2}	8.4×10^{3}
Co-58m	2.2×10^{5}	5.9×10^{6}
Co-58	1.2×10^{3}	3.2×10^{4}
Co-60	4.2×10^{1}	1.1×10^{3}

Chromium (24)		
Cr-51	3.4×10^{3}	9.2×10^{4}
Cesium (55)		
Cs-129	2.8×10^{4}	7.6×10^{5}
Cs-131	3.8×10^{3}	1.0×10^{5}
Cs-132	5.7×10^{3}	1.5×10^{5}
Cs-134m	3.0×10^{5}	8.0×10^{6}
Cs-134	4.8×10^{1}	1.3×10^{3}
Cs-135	4.3×10^{-5}	1.2×10^{-3}
Cs-136	2.7×10^{3}	7.3×10^{4}
Cs-137	3.2	8.7×10^{1}
Copper (29)		
Cu-64	1.4×10^{5}	3.9×10^{6}
Cu-67	2.8×10^{4}	7.6×10^{5}
Dysprosium (66)		
Dy-159	2.1×10^{2}	5.7×10^{3}
Dy-165	3.0×10^{5}	8.2×10^{6}
Dy-166	8.6×10^{3}	2.3×10^{5}
Erbium (68)		
Er-169	3.1×10^{3}	8.3×10^{4}
Er-171	9.0×10^{4}	2.4×10^{6}
Einsteinium (99)		
Es-253	---	---
Es-254	---	---
Es-254m	---	---
Es-255	---	---
Europium (63)		

Eu-147	1.4×10^{3}	3.7×10^{4}
Eu-148	6.0×10^{2}	1.6×10^{4}
Eu-149	3.5×10^{2}	9.4×10^{3}
Eu-150	6.1×10^{4}	1.6×10^{6}
Eu-152m	8.2×10^{4}	2.2×10^{6}
Eu-152	6.5	1.8×10^{2}
Eu-154	9.8	2.6×10^{2}
Eu-155	1.8×10^{1}	4.9×10^{2}
Eu-156	2.0×10^{3}	5.5×10^{4}
Fluorine (9)		
F-18	3.5×10^{6}	9.5×10^{7}
Iron (26)		
Fe-52	2.7×10^{5}	7.3×10^{6}
Fe-55	8.8×10^{1}	2.4×10^{3}
Fe-59	1.8×10^{3}	5.0×10^{4}
Fe-60	7.4×10^{-4}	2.0×10^{-2}
Fermium (100)		
Fm-255	---	---
Fm-257	---	---
Gallium (31)		
Ga-67	2.2×10^{4}	6.0×10^{5}
Ga-68	1.5×10^{6}	4.1×10^{7}
Ga-72	1.1×10^{5}	3.1×10^{6}
Gadolinium (64)		
Gd-146	6.9×10^{2}	1.9×10^{4}
Gd-148	1.2	3.2×10^{1}
Gd-153	1.3×10^{2}	3.5×10^{3}

Gd-159	3.9×10^{4}	1.1×10^{6}
Germanium (32)		
Ge-68	2.6×10^{2}	7.1×10^{3}
Ge-71	5.8×10^{3}	1.6×10^{5}
Ge-77	1.3×10^{5}	3.6×10^{6}
Hydrogen (1)		
H-3 (T)	3.6×10^{2}	9.7×10^{3}
Hafnium (72)		
Hf-172	4.1×10^{1}	1.1×10^{3}
Hf-175	3.9×10^{2}	1.1×10^{4}
Hf-181	6.3×10^{2}	1.7×10^{4}
Hf-182	8.1×10^{-6}	2.2×10^{-4}
Mercury (80)		
Hg-194	1.3×10^{-1}	3.5
Hg-195m	1.5×10^{4}	4.0×10^{5}
Hg-197m	2.5×10^{4}	6.7×10^{5}
Hg-197	9.2×10^{3}	2.5×10^{5}
Hg-203	5.1×10^{2}	1.4×10^{4}
Holmium (67)		
Ho-163	2.7	7.6×10^{1}
Ho-166m	6.6×10^{-2}	1.8
Ho-166	2.6×10^{4}	7.0×10^{5}
Iodine (53)		
I-123	7.1×10^{4}	1.9×10^{6}
I-124	9.3×10^{3}	2.5×10^{5}
I-125	6.4×10^{2}	1.7×10^{4}
I-126	2.9×10^{3}	8.0×10^{4}

I-129	6.5×10^{-6}	1.8×10^{-4}
I-131	4.6×10^{3}	1.2×10^{5}
I-132	3.8×10^{5}	1.0×10^{7}
I-133	4.2×10^{4}	1.1×10^{6}
I-134	9.9×10^{5}	2.7×10^{7}
I-135	1.3×10^{5}	3.5×10^{6}
Indium (49)		
In-111	1.5×10^{4}	4.2×10^{5}
In-113m	6.2×10^{5}	1.7×10^{7}
In-114m	8.6×10^{2}	2.3×10^{4}
In-115m	2.2×10^{5}	6.1×10^{6}
Iridium (77)		
Ir-189	1.9×10^{3}	5.2×10^{4}
Ir-190	2.3×10^{3}	6.2×10^{4}
Ir-192	3.4×10^{2}	9.2×10^{3}
Ir-193m	2.4×10^{3}	6.4×10^{4}
Ir-194	3.1×10^{4}	8.4×10^{5}
Potassium (19)		
K-40	2.4×10^{-7}	6.4×10^{-6}
K-42	2.2×10^{5}	6.0×10^{6}
K-43	1.2×10^{5}	3.3×10^{6}
Krypton (36)		
Kr-79	4.2×10^{4}	1.1×10^{6}
Kr-81	7.8×10^{-4}	2.1×10^{-2}
Kr-85m	3.0×10^{5}	8.2×10^{6}
Kr-85	1.5×10^{1}	3.9×10^{2}
Kr-87	1.0×10^{6}	2.8×10^{7}

Lanthanum (57)		
La-137	1.6×10^{-3}	4.4×10^{-2}
La-140	2.1×10^{4}	5.6×10^{5}
Lutetium (71)		
Lu-172	4.2×10^{3}	1.1×10^{5}
Lu-173	5.6×10^{1}	1.5×10^{3}
Lu-174m	2.0×10^{2}	5.3×10^{3}
Lu-174	2.3×10^{1}	6.2×10^{2}
Lu-177	4.1×10^{3}	1.1×10^{5}
Magnesium (12)		
Mg-28	2.0×10^{5}	5.4×10^{6}
Manganese (25)		
Mn-52	1.6×10^{4}	4.4×10^{5}
Mn-53	6.8×10^{-5}	1.8×10^{-3}
Mn-54	2.9×10^{2}	7.7×10^{3}
Mn-56	8.0×10^{5}	2.2×10^{7}
Molybdenum (42)		
Mo-93	4.1×10^{-2}	1.1
Mo-99	1.8×10^{4}	4.8×10^{5}
Nitrogen (7)		
N-13	5.4×10^{7}	1.5×10^{9}
Sodium (11)		
Na-22	2.3×10^{2}	6.3×10^{3}
Na-24	3.2×10^{5}	8.7×10^{6}
Niobium (41)		
Nb-92m	5.2×10^{3}	1.4×10^{5}

Nb-93m	8.8	2.4×10^{2}
Nb-94	6.9×10^{-3}	1.9×10^{-1}
Nb-95	1.5×10^{3}	3.9×10^{4}
Nb-97	9.9×10^{5}	2.7×10^{7}
Neodymium (60)		
Nd-147	3.0×10^{3}	8.1×10^{4}
Nd-149	4.5×10^{5}	1.2×10^{7}
Nickel (28)		
Ni-59	3.0×10^{-3}	8.0×10^{-2}
Ni-63	2.1	5.7×10^{1}
Ni-65	7.1×10^{5}	1.9×10^{7}
Neptunium (93)		
Np-235	5.2×10^{1}	1.4×10^{3}
Np-236	4.7×10^{-4}	1.3×10^{-2}
Np-237	2.6×10^{-5}	7.1×10^{-4}
Np-239	8.6×10^{3}	2.3×10^{5}
Osmium (76)		
Os-185	2.8×10^{2}	7.5×10^{3}
Os-191m	4.6×10^{4}	1.3×10^{6}
Os-191	1.6×10^{3}	4.4×10^{4}
Os-193	2.0×10^{4}	5.3×10^{5}
Os-194	1.1×10^{1}	3.1×10^{2}
Phosphorus (15)		
P-32	1.1×10^{4}	2.9×10^{5}
P-33	5.8×10^{3}	1.6×10^{5}
Protactinium (91)		
Pa-230	1.2×10^{3}	3.3×10^{4}

Pa-231	1.7×10^{-3}	4.7×10^{-2}
Pa-233	7.7×10^{2}	2.1×10^{4}
Lead (82)		
Pb-201	6.2×10^{4}	1.7×10^{6}
Pb-202	1.2×10^{-4}	3.4×10^{-3}
Pb-203	1.1×10^{4}	3.0×10^{5}
Pb-205	4.5×10^{-6}	1.2×10^{-4}
Pb-210	2.8	7.6×10^{1}
Pb-212	5.1×10^{4}	1.4×10^{6}
Palladium (46)		
Pd-103	2.8×10^{3}	7.5×10^{4}
Pd-107	1.9×10^{-5}	5.1×10^{-4}
Pd-109	7.9×10^{4}	2.1×10^{6}
Promethium (61)		
Pm-143	1.3×10^{2}	3.4×10^{3}
Pm-144	9.2×10^{1}	2.5×10^{3}
Pm-145	5.2	1.4×10^{2}
Pm-147	3.4×10^{1}	9.3×10^{2}
Pm-148m	7.9×10^{2}	2.1×10^{4}
Pm-149	1.5×10^{4}	4.0×10^{5}
Pm-151	2.7×10^{4}	7.3×10^{5}
Polonium (84)		
Po-208	2.2×10^{1}	5.9×10^{2}
Po-209	6.2×10^{-1}	1.7×10^{1}
Po-210	1.7×10^{2}	4.5×10^{3}
Praseodymium (59)		
Pr-142	4.3×10^{4}	1.2×10^{6}

Pr-143	2.5×10^{3}	6.7×10^{4}
Platinum (78)		
Pt-188	2.5×10^{3}	6.8×10^{4}
Pt-191	8.7×10^{3}	2.4×10^{5}
Pt-193m	5.8×10^{3}	1.6×10^{5}
Pt-193	1.4	3.7×10^{1}
Pt-195m	6.2×10^{3}	1.7×10^{5}
Pt-197m	3.7×10^{5}	1.0×10^{7}
Pt-197	3.2×10^{4}	8.7×10^{5}
Plutonium (94)		
Pu-236	2.0×10^{1}	5.3×10^{2}
Pu-237	4.5×10^{2}	1.2×10^{4}
Pu-238	6.3×10^{-1}	1.7×10^{1}
Pu-239	2.3×10^{-3}	6.2×10^{-2}
Pu-240	8.4×10^{-3}	2.3×10^{-1}
Pu-241	3.8	1.0×10^{2}
Pu-242	1.5×10^{-4}	3.9×10^{-3}
Pu-244	6.7×10^{-7}	1.8×10^{-5}
Radium (88)		
Ra-223	1.9×10^{3}	5.1×10^{4}
Ra-224	5.9×10^{3}	1.6×10^{5}
Ra-225	1.5×10^{3}	3.9×10^{4}
Ra-226	3.7×10^{-2}	1.0
Ra-228	1.0×10^{1}	2.7×10^{2}
Rubidium (37)		
Rb-81	3.1×10^{5}	8.4×10^{6}
Rb-83	6.8×10^{2}	1.8×10^{4}

Rb-84	1.8×10^{3}	4.7×10^{4}
Rb-86	3.0×10^{3}	8.1×10^{4}
Rb-87	3.2×10^{-9}	8.6×10^{-8}
Rb (natural)	6.7×10^{6}	1.8×10^{8}
Rhenium (75)		
Re-183	3.8×10^{2}	1.0×10^{4}
Re-184m	1.6×10^{2}	4.3×10^{3}
Re-184	6.9×10^{2}	1.9×10^{4}
Re-186	6.9×10^{3}	1.9×10^{5}
Re-187	1.4×10^{-9}	3.8×10^{-8}
Re-188	3.6×10^{4}	9.8×10^{5}
Re-189	2.5×10^{4}	6.8×10^{5}
Re (natural)	---	2.4×10^{-8}
Rhodium (45)		
Rh-99	3.0×10^{3}	8.2×10^{4}
Rh-101	4.1×10^{1}	1.1×10^{3}
Rh-102m	2.3×10^{2}	6.2×10^{3}
Rh-102	4.5×10^{1}	1.2×10^{3}
Rh-103m	1.2×10^{6}	3.3×10^{7}
Rh-105	3.1×10^{4}	8.4×10^{5}
Radon (86)		
Rn-222	5.7×10^{3}	1.5×10^{5}
Ruthenium (44)		
Ru-97	1.7×10^{4}	4.6×10^{5}
Ru-103	1.2×10^{3}	3.2×10^{4}
Ru-105	2.5×10^{5}	6.7×10^{6}
Ru-106	1.2×10^{2}	3.3×10^{3}

Sulfur (16)		
S-35	1.6×10^{3}	4.3×10^{4}
Antimony (51)		
Sb-122	1.5×10^{4}	4.0×10^{5}
Sb-124	6.5×10^{2}	1.7×10^{4}
Sb-125	3.9×10^{1}	1.0×10^{3}
Sb-126	3.1×10^{3}	8.4×10^{4}
Scandium (21)		
Sc-44	6.7×10^{5}	1.8×10^{7}
Sc-46	1.3×10^{3}	3.4×10^{4}
Sc-47	3.1×10^{4}	8.3×10^{5}
Sc-48	5.5×10^{4}	1.5×10^{6}
Selenium (34)		
Se-75	5.4×10^{2}	1.5×10^{4}
Se-79	2.6×10^{-3}	7.0×10^{-2}
Silicon (14)		
Si-31	1.4×10^{6}	3.9×10^{7}
Si-32	3.9	1.1×10^{2}
Samarium (62)		
Sm-145	9.8×10^{1}	2.6×10^{3}
Sm-147	8.5×10^{-1}	2.3×10^{-8}
Sm-151	9.7×10^{-1}	2.6×10^{1}
Sm-153	1.6×10^{4}	4.4×10^{5}
Tin (50)		
Sn-113	3.7×10^{2}	1.0×10^{4}
Sn-117m	3.0×10^{3}	8.2×10^{4}
Sn-119m	1.4×10^{2}	3.7×10^{3}

Sn-121m	2.0	5.4×10^{1}
Sn-123	3.0×10^{2}	8.2×10^{3}
Sn-125	4.0×10^{3}	1.1×10^{5}
Sn-126	1.0×10^{-3}	2.8×10^{-2}
Strontium (38)		
Sr-82	2.3×10^{3}	6.2×10^{4}
Sr-85m	1.2×10^{6}	3.3×10^{7}
Sr-85	8.8×10^{2}	2.4×10^{4}
Sr-87m	4.8×10^{5}	1.3×10^{7}
Sr-89	1.1×10^{3}	2.9×10^{4}
Sr-90	5.1	1.4×10^{2}
Sr-91	1.3×10^{5}	3.6×10^{6}
Sr-92	4.7×10^{5}	1.3×10^{7}
Tritium (1)		
T (H-3)	3.6×10^{2}	9.7×10^{3}
Tantalum (73)		
Ta-178	4.2×10^{6}	1.1×10^{8}
Ta-179	4.1×10^{1}	1.1×10^{3}
Ta-182	2.3×10^{2}	6.2×10^{3}
Terbium (65)		
Tb-157	5.6×10^{-1}	1.5×10^{1}
Tb-158	5.6×10^{-1}	1.5×10^{1}
Tb-160	4.2×10^{2}	1.1×10^{4}
Technetium (43)		
Tc-95m	8.3×10^{2}	2.2×10^{4}
Tc-96m	1.4×10^{6}	3.8×10^{7}
Tc-96	1.2×10^{4}	3.2×10^{5}

Tc-97m	5.6×10^{2}	1.5×10^{4}
Tc-97	5.2×10^{-5}	1.4×10^{-3}
Tc-98	3.2×10^{-5}	8.7×10^{-4}
Tc-99m	1.9×10^{5}	5.3×10^{6}
Tc-99	6.3×10^{-4}	1.7×10^{-2}
Tellurium (52)		
Te-118	6.8×10^{3}	1.8×10^{5}
Te-121m	2.6×10^{2}	7.0×10^{3}
Te-121	2.4×10^{3}	6.4×10^{4}
Te-123m	3.3×10^{2}	8.9×10^{3}
Te-125m	6.7×10^{2}	1.8×10^{4}
Te-127m	3.5×10^{2}	9.4×10^{3}
Te-127	9.8×10^{4}	2.6×10^{6}
Te-129m	1.1×10^{3}	3.0×10^{4}
Te-129	7.7×10^{5}	2.1×10^{7}
Te-131m	3.0×10^{4}	8.0×10^{5}
Te-132	1.1×10^{4}	3.0×10^{5}
Thorium (90)		
Th-227	1.1×10^{3}	3.1×10^{4}
Th-228	3.0×10^{1}	8.2×10^{2}
Th-229	7.9×10^{-3}	2.1×10^{-1}
Th-230	7.6×10^{-4}	2.1×10^{-2}
Th-231	2.0×10^{4}	5.3×10^{5}
Th-232	4.0×10^{-9}	1.1×10^{-7}
Th-234	8.6×10^{2}	2.3×10^{4}
Th (natural)	8.1×10^{-9}	2.2×10^{-7}
Titanium (22)		
Ti-44	6.4	1.7×10^{2}

Thallium (81)		
Tl-200	2.2×10^{4}	6.0×10^{5}
Tl-201	7.9×10^{3}	2.1×10^{5}
Tl-202	2.0×10^{3}	5.3×10^{4}
Tl-204	1.7×10^{1}	4.6×10^{2}
Thulium (69)		
Tm-167	3.1×10^{3}	8.5×10^{4}
Tm-168	3.1×10^{2}	8.3×10^{3}
Tm-170	2.2×10^{2}	6.0×10^{3}
Tm-171	4.0×10^{1}	1.1×10^{3}
Uranium (92)		
U-230	1.0×10^{3}	2.7×10^{4}
U-232	8.3×10^{-1}	2.2×10^{1}
U-233	3.6×10^{-4}	9.7×10^{-3}
U-234	2.3×10^{-4}	6.2×10^{-3}
U-235	8.0×10^{-8}	2.2×10^{-6}
U-236	2.4×10^{-6}	6.5×10^{-5}
U-238	1.2×10^{-8}	3.4×10^{-7}
U (natural)	2.6×10^{-8}	7.1×10^{-7}
U (enriched 5% or less)	---	(See part 4731.0424)
U (enriched more than 5%)	---	(See part 4731.0424)
U (depleted)	---	(See part 4731.0424)
Vanadium (23)		
V-48	6.3×10^{3}	1.7×10^{5}
V-49	3.0×10^{2}	8.1×10^{3}
Tungsten (74)		
W-178	1.3×10^{3}	3.4×10^{4}

W-181	2.2×10^{2}	6.0×10^{3}
W-185	3.5×10^{2}	9.4×10^{3}
W-187	2.6×10^{4}	7.0×10^{5}
W-188	3.7×10^{2}	1.0×10^{4}
Xenon (54)		
Xe-122	4.8×10^{4}	1.3×10^{6}
Xe-123	4.4×10^{5}	1.2×10^{7}
Xe-127	1.0×10^{3}	2.8×10^{4}
Xe-131m	3.1×10^{3}	8.4×10^{4}
Xe-133	6.9×10^{3}	1.9×10^{5}
Xe-135	9.5×10^{4}	2.6×10^{6}
Yttrium (39)		
Y-87	1.7×10^{4}	4.5×10^{5}
Y-88	5.2×10^{2}	1.4×10^{4}
Y-90	2.0×10^{4}	5.4×10^{5}
Y-91m	1.5×10^{6}	4.2×10^{7}
Y-91	9.1×10^{2}	2.5×10^{4}
Y-92	3.6×10^{5}	9.6×10^{6}
Y-93	1.2×10^{5}	3.3×10^{6}
Ytterbium (70)		
Yb-169	8.9×10^{2}	2.4×10^{4}
Yb-175	6.6×10^{3}	1.8×10^{5}
Zinc (30)		
Zn-65	3.0×10^{2}	8.2×10^{3}
Zn-69m	1.2×10^{5}	3.3×10^{6}
Zn-69	1.8×10^{6}	4.9×10^{7}
Zirconium (40)		

Zr-88	6.6×10^{2}	1.8×10^{4}
Zr-93	9.3×10^{-5}	2.5×10^{-3}
Zr-95	7.9×10^{2}	2.1×10^{4}
Zr-97	7.1×10^{4}	1.9×10^{6}

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

Element and atomic number and symbol of radionuclide	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Actinium (89)				
Ac-225	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ac-227	1.0×10^{-1}	2.7×10^{-12}	1.0×10^{3}	2.7×10^{-8}
Ac-228	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Silver (47)				
Ag-105	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ag-108m[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-110m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-111	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Aluminum (13)				
Al-26	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Americium (95)				
Am-241	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Am-242m[a]	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Am-243[a]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Argon (18)				

Ar-37	1.0×10^{6}	2.7×10^{-5}	1.0×10^{8}	2.7×10^{-3}
Ar-39	1.0×10^{7}	2.7×10^{-4}	1.0×10^{4}	2.7×10^{-7}
Ar-41	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Arsenic (33)				
As-72	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
As-73	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
As-74	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
As-76	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
As-77	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Astatine (85)				
At-211	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Gold (79)				
Au-193	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Au-194	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Au-195	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Au-198	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Au-199	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Barium (56)				
Ba-131	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-133	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-133m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-140[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Beryllium (4)				
Be-7	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Be-10	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Bismuth (83)				
Bi-205	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}

Bi-206	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Bi-207	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Bi-210	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Bi-210m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Bi-212[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Berkelium (97)				
Bk-247	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Bk-249	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Bromine (35)				
Br-76	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Br-77	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Br-82	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Carbon(6)				
C-11	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
C-14	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Calcium (20)				
Ca-41	1.0×10^{5}	2.7×10^{-6}	1.0×10^{7}	2.7×10^{-4}
Ca-45	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Ca-47	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Cadmium (48)				
Cd-109	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Cd-113m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Cd-115	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cd-115m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Cerium (58)				
Ce-139	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ce-141	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}

Ce-143	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ce-144[a]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Californium (98)				
Cf-248	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-249	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cf-250	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-251	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cf-252	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-253	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cf-254	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Chlorine (17)				
Cl-36	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Cl-38	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Curium (96)				
Cm-240	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cm-241	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cm-242	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cm-243	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Cm-244	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cm-245	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cm-246	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cm-247	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Cm-248	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cobalt (27)				
Co-55	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Co-56	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Co-57	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Co-58	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Co-58m	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Co-60	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Chromium (24)				
Cr-51	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Cesium (55)				
Cs-129	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cs-131	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Cs-132	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-134	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cs-134m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Cs-135	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Cs-136	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-137[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Copper (29)				
Cu-64	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cu-67	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Dysprosium (66)				
Dy-159	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Dy-165	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Dy-166	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Erbium (68)				
Er-169	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Er-171	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Europium (63)				
Eu-147	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Eu-148	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-149	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Eu-150 (short-lived)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Eu-150 (long-lived)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-152	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-152m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Eu-154	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-155	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Eu-156	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fluorine (9)				
F-18	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Iron (26)				
Fe-52	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fe-55	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Fe-59	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fe-60	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Gallium (31)				
Ga-67	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ga-68	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Ga-72	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Gadolinium (64)				
Gd-146	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Gd-148	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Gd-153	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Gd-159	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Germanium (32)				
Ge-68	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

Ge-71	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Ge-77	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Tritium (1)				
H-3 (T)	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Hafnium (72)				
Hf-172	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hf-175	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hf-181	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hf-182	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Mercury (80)				
Hg-194	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hg-195m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hg-197	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Hg-197m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hg-203	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Holmium (67)				
Ho-166	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Ho-166m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Iodine (53)				
I-123	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
I-124	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
I-125	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
I-126	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
I-129	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
I-131	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
I-132	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
I-133	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}

I-134	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
I-135	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Indium (49)				
In-111	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-113m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-114m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-115m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Iridium (77)				
Ir-189	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Ir-190	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ir-192	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ir-194	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Potassium (19)				
K-40	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
K-42	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
K-43	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Krypton (36)				
Kr-79	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Kr-81	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Kr-85	1.0×10^{5}	2.7×10^{-6}	1.0×10^{4}	2.7×10^{-7}
Kr-85m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
Kr-87	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Lanthanum (57)				
La-137	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
La-140	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Lutetium (71)				
Lu-172	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}

Lu-173	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-174	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-174m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-177	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Magnesium (12)				
Mg-28	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Manganese (25)				
Mn-52	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Mn-53	1.0×10^{4}	2.7×10^{-7}	1.0×10^{9}	2.7×10^{-2}
Mn-54	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Mn-56	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Molybdenum (42)				
Mo-93	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Mo-99	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Nitrogen (7)				
N-13	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Sodium (11)				
Na-22	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Na-24	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Niobium (41)				
Nb-93m	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Nb-94	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Nb-95	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Nb-97	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Neodymium (60)				
Nd-147	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Nd-149	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Nickel (28)				
Ni-59	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Ni-63	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Ni-65	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Neptunium (93)				
Np-235	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Np-236 (short-lived)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Np-236 (long-lived)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Np-237[a]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Np-239	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Osmium (76)				
Os-185	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Os-191	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Os-191m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Os-193	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Os-194	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Phosphorus (15)				
P-32	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
P-33	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Protactinium (91)				
Pa-230	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pa-231	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Pa-233	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lead (82)				
Pb-201	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pb-202	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}

Pb-203	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pb-205	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pb-210[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Pb-212[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Palladium (46)				
Pd-103	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Pd-107	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Pd-109	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Promethium (61)				
Pm-143	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pm-144	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pm-145	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pm-147	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pm-148m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pm-149	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pm-151	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Polonium (84)				
Po-210	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Praseodymium (59)				
Pr-142	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Pr-143	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Platinum (78)				
Pt-188	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pt-191	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pt-193	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pt-193m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pt-195m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Pt-197	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pt-197m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Plutonium (94)				
Pu-236	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Pu-237	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pu-238	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-239	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-240	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Pu-241	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Pu-242	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-244	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Radium (88)				
Ra-223[a]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ra-224[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Ra-225	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ra-226[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ra-228[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Rubidium (37)				
Rb-81	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rb-83	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Rb-84	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rb-86	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Rb-87	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Rb (nat)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Rhenium (75)				
Re-184	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Re-184m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Re-186	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Re-187	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Re-188	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Re-189	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Re (nat)	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Rhodium (45)				
Rh-99	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rh-101	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Rh-102	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rh-102m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Rh-103m	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Rh-105	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Radon (86)				
Rn-222[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{8}	2.7×10^{-3}
Ruthenium (44)				
Ru-97	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Ru-103	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ru-105	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ru-106[a]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Sulfur (16)				
S-35	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Antimony (51)				
Sb-122	1.0×10^{2}	2.7×10^{-9}	1.0×10^{4}	2.7×10^{-7}
Sb-124	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Sb-125	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sb-126	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Scandium (21)				

Sc-44	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sc-46	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Sc-47	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sc-48	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Selenium (34)				
Se-75	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Se-79	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Silicon (14)				
Si-31	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Si-32	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Samarium (62)				
Sm-145	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Sm-147	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Sm-151	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Sm-153	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tin (50)				
Sn-113	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-117m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sn-119m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-121m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-123	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Sn-125	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Sn-126	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Strontium (38)				
Sr-82	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sr-85	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sr-85m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}

Sr-87m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sr-89	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Sr-90[a]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{4}	2.7×10^{-7}
Sr-91	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sr-92	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tritium (1)				
T (H-3)	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Tantalum (73)				
Ta-178 (long-lived)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ta-179	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Ta-182	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Terbium (65)				
Tb-157	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Tb-158	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tb-160	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Technetium (43)				
Tc-95m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-96	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-96m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Tc-97	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Tc-97m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Tc-98	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-99	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Tc-99m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Tellurium (52)				
Te-121	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Te-121m	1.0×10^{2}	2.7×10^{-9}	$1.0 \times 10^{\underline{5}\underline{6}}$	$2.7 \times 10^{\underline{-6}\text{-}5}$

Te-123m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Te-125m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Te-127	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Te-127m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Te-129	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Te-129m	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Te-131m	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Te-132	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Thorium (90)				
Th-227	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Th-228[a]	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Th-229[a]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Th-230	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Th-231	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Th-232	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Th-234[a]	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Th (nat)[a]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Titanium (22)				
Ti-44	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Thallium (81)				
Tl-200	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tl-201	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tl-202	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tl-204	1.0×10^{4}	2.7×10^{-7}	1.0×10^{4}	2.7×10^{-7}
Thulium (69)				
Tm-167	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

Tm-170	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Tm-171	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Uranium (92)				
U-230 (fast lung absorption)[a,b]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-230 (medium lung absorption)[c]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-230 (slow lung absorption)[d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-232 (fast lung absorption)[a,b]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U-232 (medium lung absorption)[c]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-232 (slow lung absorption)[d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-233 (fast lung absorption)[b]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-233 (medium lung absorption)[c]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
U-233 (slow lung absorption)[d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-234 (fast lung absorption)[b]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-234 (medium lung absorption)[c]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
U-234 (slow lung absorption)[d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-235 (all lung absorption types)[a,b,c,d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-236 (fast lung absorption)[b]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-236 (medium lung absorption)[c]	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}

U-236 (slow lung absorption)[d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-238 (all lung absorption types)[a,b,c,d]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U (nat)[a]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U (enriched to 20% or less)[e]	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U (dep)	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Vanadium (23)				
V-48	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
V-49	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Tungsten (74)				
W-178	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
W-181	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
W-185	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
W-187	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
W-188	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Xenon (54)				
Xe-122	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Xe-123	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Xe-127	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Xe-131m	1.0×10^{4}	2.7×10^{-7}	1.0×10^{4}	2.7×10^{-7}
Xe-133	1.0×10^{3}	2.7×10^{-8}	1.0×10^{4}	2.7×10^{-7}
Xe-135	1.0×10^{3}	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
Yttrium (39)				
Y-87	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Y-88	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}

Y-90	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Y-91	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Y-91m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Y-92	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Y-93	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ytterbium (70)				
Yb-169	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Yb-175	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Zinc (30)				
Zn-65	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Zn-69	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Zn-69m	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Zirconium (40)				
Zr-88	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Zr-93[a]	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Zr-95	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Zr-97[a]	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

[a]Parent nuclides and their progeny included in secular equilibrium are listed ~~in the following~~ as follows:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
Ag-108m	Ag-108
Cs-137	Ba-137m
~~Ce-134~~	~~La-134~~
Ce-144	Pr-144

Ba-140	La-140
Bi-212	Tl-208(0.36), Po-212(0.64)
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
~~Rn-220~~	~~Po-216~~
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
~~Th-226~~	~~Ra-222, Rn-218, Po-214~~
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th (nat)	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-234	Pa-234m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
U-235	Th-231
U-238	Th-234, Pa-234m
U (nat)	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
~~U-240~~	~~Np-240m~~
Np-237	Pa-233
Am-242m	Am-242
Am-243	Np-239

[b]These values apply only to compounds of uranium that take the chemical form of UF_6, UO_2F_2 and $UO_2(NO_3)_2$ in both normal and accident conditions of transport.

[c]These values apply only to compounds of uranium that take the chemical form of UO_3, UF_4, UCl_4 and hexavalent compounds in both normal and accident conditions of transport.

[d]These values apply to all compounds of uranium other than those specified in notes b and c of this table.

[e]These values apply to unirradiated uranium only.

4731.0423 DETERMINATION OF A_1 AND A_2.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Subp. 5. **Activities unknown.**

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

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

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

	A_1		A_2	
Contents	(TBq)	(Ci)	(TBq)	(Ci)
Only beta- or gamma-emitting	1×10^{-1}	2.7 ~~x 10^0~~	2×10^{-2}	5.4×10^{-1}

radionuclides are known to be present				
~~Only alpha-emitting radionuclides are known to be present~~ Alpha-emitting nuclides, but no neutron emitters are known to be present[a]	2×10^{-1}	5.4 ~~$\times 10^{0}$~~	9×10^{-5}	2.4×10^{-3}
~~No relevant data are available~~ Neutron-emitting nuclides are known to be present or no relevant data are available	1×10^{-3}	2.7×10^{-2}	9×10^{-5}	2.4×10^{-3}

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

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

4731.0565 APPLICATION; FILING.

Subpart 1. **Generally.**

A. A person may apply for a specific license issued under parts 4731.0525 to 4731.0630 by filing an application according to part 4731.0200, subpart 4.

~~B. Information contained in previous applications, statements, or reports filed with the commissioner may be incorporated by reference if the references are clear and specific.~~

~~C. A license application filed under this part will be considered also to be an application for licenses authorizing other activities for which licenses are required by the commissioner, provided the application specifies the additional activities for which licenses are requested and complies with rules of the commissioner as to applications for such licenses.~~

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

~~A.~~ 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.

~~B.~~ 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.

~~C.~~ 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.]

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

Greater than 10^4 but less than or equal to 10^5 times the applicable quantities under part 4731.3160. For a combination of isotopes, if R, as defined in ~~Code of Federal Regulations, title 10, section 70.25, paragraph (a)~~ subpart 1, item A, divided by 10^4 is greater than 1 but R divided by 10^5 is less than or equal to 1.	$1,125,000
Greater than 10^3 but less than or equal to 10^4 times the applicable quantities under part 4731.3160. For a combination of isotopes, if R, as defined in ~~Code of Federal Regulations, title 10, section 70.25, paragraph (a)~~ subpart 1, item A, divided by 10^3 is greater than 1 but R divided by 10^4 is less than or equal to 1.	$225,000

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

4731.0600 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.

Subpart 1. **Expiration.**

A. ~~Except as provided in this subpart,~~ A specific license issued under parts 4731.0525 to 4731.0630 expires at the end of the ~~specified day in the month and year~~ day on the expiration date stated in the license~~.~~, unless the licensee has filed an application for renewal under part 4731.0595 not less than 30 days before the expiration date stated in the existing license.

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

~~C. The following specific licenses are not subject to, or otherwise affected, by subpart 2:~~

~~(1) a specific license for which, on February 15, 1996, an evaluation or an emergency plan is required under Code of Federal Regulations, title 10, section 70.22, paragraph (i);~~

~~(2) a specific license whose holder is subject to the financial assurance requirements under part 4731.0580 and whose holder on February 15, 1996, either:~~

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

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

~~(3) a specific license whose holder is on the list of contaminated sites maintained for the NRC's site decommissioning management plan (SDMP) and published~~

~~in Site Decommissioning Management Plan, NUREG-1444, Supplement 1 (November 1995);~~

~~(4) a specific license whose issuance, amendment, or renewal, as of February 15, 1996, is not a categorical exclusion under Code of Federal Regulations, title 10, section 51.22, paragraph (c), clause (14), and, therefore, needs an environmental assessment or environmental impact statement according to Code of Federal Regulations, title 10, part 51, subpart A; and~~

~~(5) a specific license issued according to part 4731.0585 that, as of February 15, 1996, is also subject to Code of Federal Regulations, title 10, section 70.24.~~

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

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

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

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

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

Subp. 2. **Decommissioning.**

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

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

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

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

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

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

Subp. 3. [See repealer.]

4731.0610 AUTHORIZED USE OF SPECIAL NUCLEAR MATERIAL.

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

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

4731.0620 REPORTING REQUIREMENTS.

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

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

A. A licensee must make reports required under subparts 1 and 2 ~~and Code of Federal Regulations, title 10, section 70.74, and part 70, Appendix A, if applicable,~~ by telephone to the commissioner according to part 4731.0200, subpart 5. To the extent that the information is available at the time of notification, the information provided in the report must include:

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

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

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

4731.0760 SPECIFIC LICENSE; APPLICATION.

Subpart 1. **Application generally.**

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

~~B. An applicant may incorporate by reference information contained in previous applications, statements, or reports filed with the commissioner, provided the reference is clear and specific.~~

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

~~D.~~ C. The commissioner may at any time after the filing of the original application, and before the expiration of the license, require further statements to enable the commissioner

to determine whether the application should be granted or denied or whether a license should be modified or revoked.

~~E. An application for a license under parts 4731.0700 to 4731.0840 shall be considered also as an application for licenses authorizing other activities for which licenses are required by the commissioner, provided that the application specifies the additional activities for which licenses are requested and complies with requirements for applications for such licenses.~~

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

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

4731.0790 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.

Subpart 1. **Expiration.**

A. ~~Except as provided in this subpart,~~ A specific license issued under parts 4731.0700 to 4731.0840 expires at the end of the day on the expiration date stated in the license, unless the licensee has filed an application for renewal under part 4731.0795 not less than 30 days before the expiration date stated in the existing license.

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

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

4731.0820 REPORTING REQUIREMENTS.

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

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

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

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

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

4731.2350 PROCEDURES FOR RECEIVING AND OPENING PACKAGES.

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

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

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

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

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

4731.2600 REPORTS; THEFT OR LOSS OF LICENSED MATERIAL.

Subpart 1. **Telephone reports.**

~~A.~~ A licensee must report to the commissioner by telephone, according to part 4731.0200, subpart 5, as follows:

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

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

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

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

Subp. 3. [See repealer.]

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

4731.2610 NOTIFICATION OF INCIDENTS.

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

Subp. 4. **Reporting method.** Licensees ~~having an installed emergency notification system~~ must make the reports required under this part to the ~~NRC Operations Center according to Code of Federal Regulations, title 10, section 50.72. All other licensees must make the reports required under this part by telephone to the~~ commissioner ~~or state duty officer at 1-800-422-0798~~ by telephone according to part 4731.0200, subpart 5.

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

4731.2950 LOW-LEVEL RADIOACTIVE WASTE; TRANSFER AND DISPOSAL.

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

Subp. 2. **Manifest.**

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

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

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

4731.3030 EXEMPTION; CERTAIN ITEMS CONTAINING RADIOACTIVE MATERIAL.

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

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

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

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

(3) devices in subitems (1) and (2) authorized before December 31, 2014, for use under ~~the~~ a general license ~~then provided in part 4731.3210 and equivalent regulations of the NRC or agreement states and~~, that were manufactured, tested, and labeled by the manufacturer in accordance with the specifications contained in a specific license issued by the commissioner, the NRC, or an agreement state.

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

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

4731.3065 SPECIFIC LICENSES; APPLICATION.

Subpart 1. **General requirements.**

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

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

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

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

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

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

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

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

4731.3075 TERMS AND CONDITIONS OF LICENSES.

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

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

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

4731.3085 LICENSE EXPIRATION AND TERMINATION; DECOMMISSIONING.

Subpart 1. **Expiration.**

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

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

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

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

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

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

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

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

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

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

4731.3110 REPORTING REQUIREMENTS.

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

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

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

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

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

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

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

Subp. 2. **Pharmacy licensees.**

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

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

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

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

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

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

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

4731.4030 PERFORMANCE REQUIREMENTS; INDUSTRIAL RADIOGRAPHY EQUIPMENT.

Subpart 1. **ANSI standard.**

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

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

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

Subp. 2. **Additional requirements.**

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

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

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

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

4731.4110 LABELING; PACKAGING; SECURITY.

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

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

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

4731.4140 RADIOGRAPHER TRAINING.

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

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

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

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

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

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

[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 ~~4731.0455~~ 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.]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A. Any licensee transferring category 1 quantities of radioactive material to a licensee of the ~~commission~~ commissioner, the NRC, or an agreement state, prior to conducting ~~such~~ the transfer, must verify with the NRC's license verification system or the license-issuing authority that the transferee's license authorizes the receipt of the type, form, and quantity of radioactive material to be transferred and that the licensee is authorized to receive radioactive material at the location requested for delivery. If the verification is conducted by contacting the license-issuing authority, the transferor must document the

verification. For transfers within the same organization, the licensee does not need to verify the transfer.

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

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

4731.8115 ADVANCE NOTIFICATION OF SHIPMENT OF CATEGORY 1 QUANTITIES OF RADIOACTIVE MATERIAL.

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

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

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

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

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

Subp. 5. **Cancellation notice.** Each licensee who cancels a shipment for which advance notification has been sent must send a cancellation notice to the commissioner and to the governor of each state or to the governor's designee previously notified ~~and to the NRC's Director, Division of Security Policy, Office of Nuclear Security and Incident Response~~. The licensee must send the cancellation notice before the shipment would have commenced or as soon thereafter as possible. The licensee must state in the notice that it is a cancellation and identify the advance notification that is being canceled.

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

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

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