

- (2) Neither the license nor any right under the license shall be assigned or otherwise transferred in violation of the provisions of ~~the Act~~ T.C.A. §§ 68-202-201 et seq.
- (3) Each person licensed by the Division pursuant to this Chapter shall confine has use and possession of the material licensed to the locations and purposes authorized in the license.
- (4) Each licensee authorized under ~~Rule 1200-02-10-13~~ paragraph (5) of Rule 0400-20-10-13 to distribute certain devices to generally licensed persons shall:
- (a) Report to the Division within ~~thirty~~ 30 days after the end of each calendar quarter all transfers of such devices to persons generally licensed under ~~Rule 1200-02-10-10~~ paragraph (2) of Rule 0400-20-10-10 or, if no transfers have been made during the reporting period, the report shall so indicate. For all transfers the report shall identify each general licensee by name and address, an individual by name and/or position who may constitute a point of contact between the Division and the general licensee, the type and model number of device transferred and the quantity and type of radioactive material contained in the device; and
 - (b) Furnish to each general licensee in this State to whom he transfers such device a copy of the general license contained in ~~Rule 1200-02-10-10~~ paragraph (2) of Rule 0400-20-10-10.
- (5) Each specific licensee shall notify the Division in writing when the licensee decides to permanently discontinue all activities involving radioactive materials authorized under the license.
- (6) Each licensee preparing technetium-99m radiopharmaceuticals from molybdenum-99/technetium-99m generators or rubidium-82 from strontium-82/rubidium-82 generators shall test the generator eluates for molybdenum-99 breakthrough or strontium-82 and strontium-85 contamination, respectively, in accordance with ~~Rule 1200-02-07-41~~ 0400-20-07-41. The licensee shall record the results of each test and retain each record for ~~three~~ 3 years after the record is made.
- (7) Each specific licensee and each general licensee meeting the criteria of ~~Rule 1200-02-10-10~~ part (2)(c)14 of Rule 0400-20-10-10 shall:
- (a) Provide the Division written notification, at the address in ~~Rule 1200-02-04-07~~ 0400-20-04-07, immediately following the filing of a voluntary or involuntary petition for bankruptcy under any Chapter of Title 11 (Bankruptcy) of the United States Code (U.S.C.):
 1. By or against the licensee;
 2. By or against an entity (as that term is defined in 11 U.S.C. 101(14)) controlling the licensee or listing the license or licensee as property of the estate; or
 3. By or against an affiliate (as that term is defined in 11 U.S.C. 101(2)) of the licensee;
 - (b) Include in the notification required in subparagraph (a) of this paragraph the bankruptcy court in which the petition for bankruptcy was filed; and
 - (c) Include in the notification required in subparagraph (a) of this paragraph the date of the filing of the petition.
- (8) When temporary job-sites are authorized on a specific license, radioactive material may be used at temporary job-sites, in areas not under exclusive federal jurisdiction, throughout the State of Tennessee.
- (9) Each portable gauge licensee shall use a minimum of ~~two~~ 2 independent physical controls that form tangible barriers to secure portable gauges from unauthorized removal, whenever portable gauges are not under the control and constant surveillance of the licensee.

- (10) (a) Authorization under ~~Rule 1200-02-10-14~~ paragraph (8) of Rule 0400-20-10-11 to produce Positron Emission Tomography (PET) radioactive drugs for noncommercial transfer to medical use licensees in its consortium does not relieve the licensee from complying with applicable FDA, other Federal, and Agreement State requirements governing radioactive drugs.
- (b) Each licensee authorized under ~~Rule 1200-02-10-14~~ paragraph (8) of Rule 0400-20-10-11 to produce PET radioactive drugs for noncommercial transfer to medical use licensees in its consortium shall:
1. Satisfy the labeling requirements in ~~Rule 1200-02-10-13~~ part (10)(a)4 of Rule 0400-20-10-13 for each PET radioactive drug transport radiation shield and each syringe, vial, or other container used to hold a PET radioactive drug intended for noncommercial distribution to members of its consortium; and
 2. Possess and use instrumentation to measure the radioactivity of the PET radioactive drugs intended for noncommercial distribution to members of its consortium and meet the procedural, radioactivity measurement, instrument test, instrument check, and instrument adjustment requirements in ~~Rule 1200-02-10-13~~ subparagraph (10)(c) of Rule 0400-20-10-13.
- (c) A licensee that is a pharmacy authorized under ~~Rule 1200-02-10-14~~ paragraph (8) of Rule 0400-20-10-11 to produce PET radioactive drugs for noncommercial transfer to medical use licensees in its consortium shall require that any individual that prepares PET radioactive drugs shall be:
1. An authorized nuclear pharmacist that meets the requirements in ~~Rule 1200-02-10-13~~ part (10)(b)2 of Rule 0400-20-10-13, or
 2. An individual under the supervision of an authorized nuclear pharmacist as specified in ~~Rule 1200-02-07-19~~ 0400-20-07-19.
- (d) A pharmacy, authorized under ~~Rule 1200-02-10-14~~ paragraph (8) of Rule 0400-20-10-11 to produce PET radioactive drugs for noncommercial transfer to medical use licensees in its consortium that allows an individual to work as an authorized nuclear pharmacist, shall meet the requirements of ~~Rule 1200-02-10-13~~ part (10)(b)5 of Rule 0400-20-10-13.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-17~~ 0400-20-10-17 Expiration and Termination of Licenses and Decommissioning of Sites and Separate Buildings or Outdoor Areas.

(1) Expiration of specific licenses.

Except as provided in ~~1200-02-10-17~~ paragraph (2) of this rule, each specific license shall expire at the end of the day, in the month and year stated therein.

(2) Termination of specific licenses:

(a) Specific licenses shall continue in effect, beyond the expiration date if necessary, with respect to possession of radioactive material until the Division notifies the licensee in writing that the license is terminated. During this time, the licensee shall:

1. Limit actions involving radioactive material to those related to decommissioning; and
2. Continue to control entry to restricted areas until they are suitable for release in accordance with Division requirements.

- (b) Specific licenses, including expired licenses, will be terminated by written notice to the licensee when the Division determines that:
1. The licensee has properly disposed of radioactive material;
 2. The licensee has made reasonable effort to eliminate residual radioactive contamination, if present;
 3. The premises are suitable for release in accordance with Division requirements. The licensee may demonstrate suitability for release by:
 - (i) Performance of the radiation survey described in ~~4200-02-10-17~~ part (3)(d)2 of this rule, or
 - (ii) Submission of other information that the Division determines is acceptable;
 4. The licensee has complied with any requests for information from the Division; and
 5. The licensee has submitted a written request for license termination to the Division.
- (3) Decommissioning of sites or separate buildings or outdoor areas:
- (a) Each specific licensee shall notify the Division in writing, at the address in ~~4200-02-04-07~~ Rule 0400-20-04-07, within 60 days of any of the following occurrences:
1. The license has expired pursuant to ~~4200-02-10-17~~ paragraph (2) of this rule;
 2. The licensee has decided to permanently cease principal activities, as defined in this rule:
 - (i) At the entire site, or
 - (ii) In any separate building or outdoor area that contains residual radioactivity such that the building or outdoor area is unsuitable for release in accordance with Division requirements;
 3. No principal activities under the license have been conducted for 24 months; or
 4. No principal activities have been conducted for 24 months in any separate building or outdoor area that contains residual radioactivity such that the building or outdoor area is unsuitable for release in accordance with Division requirements.
- (b) Each specific licensee:
1. If not required by ~~4200-02-10-17(3)~~ subparagraph (g) of this paragraph to submit a decommissioning plan, shall begin decommissioning its site or any separate building or outdoor area that contains residual radioactivity within 60 days of any occurrence listed in ~~4200-02-10-17(3)~~ subparagraph (a) of this paragraph.
 2. If required by ~~4200-02-10-17(3)~~ subparagraph (g) of this paragraph to submit a decommissioning plan, shall:
 - (i) Submit a decommissioning plan within 12 months of notification of any occurrence listed in ~~4200-02-10-17(3)~~ subparagraph (a) of this paragraph, and
 - (ii) Begin decommissioning upon Division approval of that plan.

- (c) Coincident with the notification required by ~~4200-02-10-17(3)~~ subparagraph (a) of this paragraph, the specific licensee shall maintain in effect all financial assurances that were established, pursuant to ~~4200-02-10-12~~ paragraph (3) of Rule ~~0400-20-10-12~~ in conjunction with a license issuance or renewal, or that are required by this rule.
1. The Division will determine if the licensee shall increase, or may decrease, the amount of the financial assurance to cover the detailed cost estimate for decommissioning established pursuant to ~~4200-02-10-17(3)~~ part (i)5 of this paragraph.
 2. The licensee may with Division approval reduce the amount of the financial assurance as decommissioning proceeds and radiological contamination is reduced at the site.
- (d) As the final steps in decommissioning, specific licensees shall:
1. Certify the disposition of all licensed material, including accumulated wastes; and
 2. Demonstrate that the premises are suitable for release in accordance with Division requirements.
 - (i) The licensee shall:
 - (I) Conduct a radiation survey of the premises where the licensed activities were carried out and submit a report of the results of this survey, or
 - (II) Submit other information that the Division determines is acceptable.
 - (ii) The licensee shall, as appropriate:
 - (I) Report levels of gamma radiation in units of microroentgens (millisieverts) per hour at 1 meter from surfaces, and
 - (II) Report levels of radioactivity, including alpha and beta, in units of
 - I. Disintegrations per minute or microcuries (megabecquerels) per 100 square centimeters — removable and fixed — for surfaces,
 - II. Microcuries (megabecquerels) per milliliter for water, and
 - III. Picocuries (becquerels) per gram for solids such as soils or concrete, and
 - (III) Specify the survey instrument(s) used and certify that each instrument was properly calibrated and tested at the time of the survey.
 3. Records required by paragraphs (4) and (6) of Rule ~~4200-02-10-26~~ 0400-20-10-26 have been received.
- (e) Except as provided in ~~4200-02-10-17(3)~~ part (k)3 of this paragraph, specific licensees shall complete decommissioning of the site or separate building or outdoor area so that the site, building or outdoor area is suitable for release in accordance with Division requirements as soon as practicable but no later than 24 months following the initiation of decommissioning.
- (f) Except as provided in ~~4200-02-10-17(3)~~ part (k)3 of this paragraph, when decommissioning involves the entire site, the specific licensee shall request license termination as soon as practicable but no later than 24 months following the initiation of decommissioning.

- (g) A specific licensee shall submit a decommissioning plan if:
1. Required to do so by license condition; or
 2. The Division determines that the procedures and activities necessary to carry out decommissioning of the site or separate building or outdoor area have not been previously approved by the Division and that these procedures could increase potential health and safety impacts to workers or to the public. Some examples are procedures:
 - (i) That would involve techniques not applied routinely during cleanup or maintenance operations;
 - (ii) In which workers would be entering areas not normally occupied where surface contamination and radiation levels are significantly higher than routinely encountered during operation;
 - (iii) That could result in significantly greater airborne concentrations of radioactive materials than are present during operation; or
 - (iv) That could result in significantly greater releases of radioactive material to the environment than those associated with operation.
- (h) Specific licensees shall not carry out procedures with potential health and safety impacts before Division approval of the decommissioning plan.
- (i) The proposed decommissioning plan for the site or separate building or outdoor area shall include:
1. A description of the conditions of the site or separate building or outdoor area sufficient to evaluate the acceptability of the plan;
 2. A description of planned decommissioning activities;
 3. A description of methods used to ensure protection of workers and the environment against radiation hazards during decommissioning;
 4. A description of the planned final radiation survey;
 5. A detailed cost estimate for decommissioning, comparison of that estimate with present funds set aside for financial assurance, and a plan for assuring the availability of adequate funds for completion of decommissioning; and
 6. For decommissioning plans calling for completion of decommissioning later than 24 months after plan approval, the plan shall include a justification for the delay based on the criteria in ~~1200-02-10-17(3)~~ part (k)3 of this paragraph.
- (j) The Division will approve the proposed decommissioning plan if the information in the plan demonstrates that the licensee:
1. Will complete decommissioning as soon as practicable; and
 2. Will adequately protect the health and safety of workers and the public.
- (k) Requests for extensions:
1. A licensee may request a delay in initiating decommissioning.

- (i) The Division may grant this delay, if the Division determines that this delay is not detrimental to the public health and safety and is otherwise in the public interest.
 - (ii) The request for a delay shall be submitted no later than 30 days before notification pursuant to ~~4200-02-10-17(3)~~ subparagraph (a) of this paragraph.
 - (iii) The schedule for decommissioning set forth in ~~4200-02-10-17(3)~~ subparagraph (b) of this paragraph shall not start until the Division has made a determination on the request.
2. A licensee may request an alternative schedule for the submittal of a decommissioning plan. The Division may approve the alternative schedule, if the Division determines that the alternative schedule is necessary to the effective conduct of decommissioning operations and presents no undue risk from radiation to the public health and safety and is otherwise in the public interest.
3. A licensee may request an alternative schedule for the completion of decommissioning of the site or separate building or outdoor area, and license termination if appropriate. The Division may approve the alternative schedule for completion of decommissioning, if the Division determines that it is warranted by consideration of the following:
- (i) Whether it is technically feasible to complete decommissioning within the allotted 24-month period;
 - (ii) Whether sufficient waste disposal capacity is available to allow completion of decommissioning within the allotted 24 month period;
 - (iii) Whether allowing short-lived radionuclides to decay will achieve a significant volume reduction in wastes requiring disposal;
 - (iv) Whether allowing short-lived radionuclides to decay will achieve a significant reduction in radiation exposure to workers;
 - (v) Other site-specific factors that the Division may determine are beyond the control of the licensee.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-18~~ 0400-20-10-18 Renewal of License.

- (1) Applications for renewal of specific licenses shall be filed in accordance with ~~4200-02-10-11~~ Rule 0400-20-10-11.
- (2) In any case in which a licensee, not less than ~~thirty~~ 30 days prior to expiration of his existing license, has filed an application in proper form for renewal or for a new license authorizing the same activities, such existing license shall not expire until the application has been finally determined by the Division.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-19~~ 0400-20-10-19 Amendment of Licenses at Request of Licensee.

Applications for amendment of a license shall be filed in accordance with ~~4200-02-10-11~~ Rule 0400-20-10-11 and shall specify the respects in which the licensee desires his license to be amended and the grounds for such amendment.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-20~~ 0400-20-10-20 Division Action on Application to Renew or Amend.

In considering an application by a licensee to renew or amend his license, the Division will apply the criteria set forth in ~~1200-02-10-12~~ Rules 0400-20-10-12 and ~~1200-02-10-13~~ 0400-20-10-13, as applicable.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-21~~ 0400-20-10-21 Inalienability of Licenses.

No license issued or granted under this Chapter and no right to possess or utilize radioactive material granted by any license issued pursuant to this Chapter shall be transferred, assigned, or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of any license to any person unless the Division shall, after securing full information, find that the transfer is in accordance with the provisions of ~~the Act~~ T.C.A. §§ 68-202-201 et seq., and shall give its consent in writing.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-22~~ 0400-20-10-22 Transfer of Material.

- (1) No licensee shall transfer radioactive material except as authorized pursuant to this rule.
- (2) Any licensee may transfer radioactive material:
 - (a) To the Division provided such transfer is accepted by the Division in writing;
 - (b) To the U.S. Department of Energy;
 - (c) To any person exempt from the regulations in this Chapter to the extent permitted under such exemption;
 - (d) To any person authorized to receive such material under terms of a general license or its equivalent, or a specific license or equivalent licensing document, issued by the Division, the U.S. Nuclear Regulatory Commission, any Agreement State or a Licensing State; or
 - (e) As otherwise authorized by the Division in writing.
- (3) Before transferring sources of radiation to a specific licensee of the Division, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State, or to a general licensee who is required to register with or report to the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State prior to receipt of the source of radiation, the transferor of the source of radiation shall verify that the transferee's authorization is for the receipt of the type, form, and quantity of the source of radiation to be transferred.
- (4) The following methods for the verification required in ~~1200-02-10-22~~ paragraph (3) of this rule are acceptable:
 - (a) The transferor may have in his possession, and read, a current copy of the transferee's specific license or registration certificate;
 - (b) The transferor may have in his possession a written certification by the transferee that he is authorized by license or registration certificate to receive the type, form and quantity of the source of radiation to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date;

- (c) For emergency shipments the transferor may accept oral certification containing all of the information specified in ~~4200-02-10-22(4)~~ subparagraph (b) of this paragraph provided that written certification is forwarded to the transferor within ~~ten~~ 10 days following the oral communication;
- (d) The transferor may obtain other information compiled by a reporting service from official records of the Division, the U.S. Nuclear Regulatory Commission or the licensing agency of any state as to the identity of licensees and the scope and expiration dates of licenses and registrations; or
- (e) When none of the methods of verification described in ~~4200-02-10-22(4)~~ subparagraphs (a) through (d) of this paragraph are readily available or when a transferor desires to verify that information received by one of such methods is correct or up-to-date, the transferor may obtain and record confirmation from the Division, the U.S. Nuclear Regulatory Commission, or the licensing agency of any state that the transferee is authorized to receive the source of radiation.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-23~~ 0400-20-10-23 Modification, Revocation, and Termination of Licenses.

- (1) The terms and conditions of all licenses may be subject to amendment, revision, or modification or the license may be suspended or revoked by reason of amendments to ~~the Act~~ T.C.A. §§ 68-202-201 et seq., or by reason of rules or regulations issued by the Department.
- (2) Any license may be revoked, suspended, or modified, in whole or in part, for any material false statement in the application or in any statement of fact required under provisions of ~~the Act~~ T.C.A. §§ 68-202-201 et seq., or because of conditions revealed by such application or statement of fact or any report, record, or inspection or other means that would warrant the Department to refuse to grant a license on an original application, or for violation of, or failure to observe any of the terms and conditions of the Act, or of the license, or of any rule or regulation of the Department. This action will be taken pursuant to ~~Tennessee Code Annotated, Chapter 23~~ T.C.A. Title 68, Chapter 202.
- (3) The Division may terminate a specific license upon request submitted by the licensee to the Division in writing.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-24~~ 0400-20-10-24 Registration.

- (1) The owner or person having possession of any radiation machine or accelerator, except those specifically exempted in ~~4200-02-10-07~~ Rule 0400-20-10-07, shall register such sources within ~~ten~~ 10 days after acquisition of such machine. The owner or possessor of any accelerator shall substitute an application for certified registration required in Chapter ~~4200-02-09~~ 0400-20-09. The application for certified registration must be received by the Department within ~~ten~~ 10 days after acquisition of the accelerator; however, an accelerator may not be energized until registered pursuant to Chapter ~~4200-02-09~~ 0400-20-09. In addition, every person who provides inspections as provided for in ~~4200-02-10-27~~ paragraph (4) of Rule 0400-20-10-27 and every person who assembles, installs, or services radiation machines shall register with the Division of Radiological Health, Tennessee Department of Environment and Conservation. Registration under this rule shall be on Department Form RHS 8-4, Form RHS 8-4a or Form RHS 8-4b, as appropriate, as furnished by the Department and may be obtained from the Division of Radiological Health, L&C Annex, 3rd Floor, 401 Church Street, Nashville, Tennessee 37243-1532. A registration fee in accordance with the Classification and Fee Schedule in ~~4200-02-10-24~~ paragraph (3) of this rule shall be due upon receipt of an invoice from the Division of Radiological Health following the submittal of the completed registration form. The check for the fee shall be made payable to "Treasurer, State of Tennessee."

(2) An annual registration fee will be due the first working day following January 1 of each year as long as the radiation machine or service is subject to registration. Each registrant shall submit the annual fee payable to, "Treasurer, State of Tennessee," in the appropriate dollar amount in accordance with the Classification and Fee Schedule in ~~Rule 4200-02-10-24~~ paragraph (3) of this rule to the Division of Radiological Health. Payment shall be accompanied by a copy of the fee invoice properly completed. The invoice for the annual fee will be dated January 17 and will require payment by March 17 of the indicated year. At the time of the annual payment a registrant of only Class II radiation machines may request specific times or list restricted hours during normal work hours for inspections pursuant to ~~Rule 4200-02-10-27~~ 0400-20-10-27 by personnel of the Division of Radiological Health, Tennessee Department of Environment and Conservation.

(3) Classification and fee schedule. For purposes of inspections and payment of fees the classification and fee schedule shall be as follows:

(a) Radiation Machines

CLASS I

Dental Radiation Machines: \$ 65 per tube

All diagnostic equipment used exclusively for dental diagnostic procedures.

CLASS II

Priority Two Medical Radiation Machines: \$ 150 per tube

All medical diagnostic x-ray equipment, not in Class III, used exclusively for medical or veterinary diagnostic procedures.

CLASS III

Priority One Medical Radiation Machines: \$ 200 per tube

All diagnostic x-ray equipment used in radiologists' offices, orthopedic surgeons' offices or hospitals exclusively for medical diagnostic procedures.

CLASS IV

Therapy Medical Radiation Machines: \$ 300 per tube

All x-ray equipment with energies less than 0.9 MeV used for the purpose of medical or veterinary radiation therapy.

CLASS V

Priority Two Industrial and Educational Radiation Machines: \$ 600 per tube

Closed-beam analytical radiation machines, gauges or industrial radiation machines used in shielded room or cabinet radiography.

CLASS VI

Priority One Industrial and Educational Radiation Machines: \$ 900 per tube

All x-ray machines used for industrial radiography and all open-beam analytical x-ray machines and all radiation machines not specifically included in Class I, II, III, IV, V or VII.

CLASS VII

Accelerators:

\$ 2,000 annual fee, plus an initial fee of \$ 375 per maximum nominal rated MeV for initial certified registration review (initial review fee not to exceed \$ 150,000)

All devices defined as accelerators as per "State Regulations for Protection Against Radiation."

- (b) A person providing assembly installation/servicing, except as provided by subparagraph ~~1200-20-10-24(3)~~ (f) of this paragraph, shall pay an annual registration fee of ~~six hundred dollars~~ \$ 600. \$ 600
- (c) A person provided assembly/installation/servicing, except as provided by subparagraph ~~1200-02-10-24(3)~~ (f) of this paragraph, shall pay an annual registration fee of ~~six hundred dollars~~ \$ 600. \$ 600
- (d) A registrant may qualify to pay a registration fee equal to ~~eighteen 18~~ percent (18%) of that listed in this paragraph (3), subject to the following conditions:
 - 1. All tubes subject to registration are inspected in accordance with paragraphs ~~1200-02-10-27~~ (3), (4) and (5) of Rule 0400-20-10-27.
 - (i) For purposes of the ~~eighteen 18~~ percent (18%) fee, the first inspection performed on an x-ray tube on or after ~~the effective date of these rules~~ December 6, 2011, will establish a new baseline date for that tube. Previous baseline dates will be reset to the last day of the month of performance of the previous inspections.
 - (I) Each subsequent inspection of a tube shall be performed during the same month as the preceding inspection or the month immediately following resulting in "baseline periods" of from 59 days to 62 days, depending upon applicable new 2 month periods, according to the schedule set out in subparagraph (3)(a) of Rule ~~1200-02-10-27~~ 0400-20-10-27.
 - (II) An inspection performed prior to or after the applicable new 2 month period shall establish a new baseline date for that tube.
 - (III) An inspection performed after the applicable new ~~two 2~~ month period shall not qualify the registrant for the ~~eighteen 18~~ percent (18%) fee.
 - (IV) An inspection performed prior to the applicable new 2 month period and meeting all other requirements found in paragraphs (3), (4) and (5) of Rule ~~1200-02-10-27~~ 0400-20-10-27 shall qualify the registrant for the ~~eighteen 18~~ percent (18%) fee.
 - (ii) Reserved.
 - 2. Each newly acquired tube subject to registration is inspected within ~~six 6~~ months of ownership or possession.

3. An individual who satisfies the requirements in paragraph ~~4200-02-10-.27~~ (4) of Rule 0400-20-10-.27 performs all inspections.
4. The registrant submits to the Division, at L&C Annex, 3rd Floor, 401 Church Street, Nashville, TN 37243-1532:
 - (i) Copies of the appropriate State evaluation forms within 60 days after the inspection.
 - (ii) Copies of applicable service reports to document correction of any deficiencies noted within 60 days after the inspection.
 - (iii) A signed "X-Ray Inspection Notification and Certification of Compliance" form within 60 days of the inspection.
5. Inspections found by the Division to be unsatisfactory under this subparagraph or under paragraph ~~4200-02-10-.27~~ (4) or (5) of Rule 0400-20-10-.27 shall not qualify for the 18 percent ~~(18%)~~.
 - (i) The registrant shall correct and re-submit the report(s) and documentation of an inspection found to be unsatisfactory within 30 days of the date of notification by the Division. Failure to correct and re-submit the report(s) and documentation of an unsatisfactory inspection will subject the registrant to the Division's normal enforcement actions, penalties and assessments.
 - (ii) The 30-day correction period shall not establish a new baseline. It shall not:
 - (I) Qualify an existing tube for reduced fee for the following calendar year, or
 - (II) Qualify a newly acquired tube for reduced fee for the current calendar year.
- (e) Reserved.
- (f) A person providing inspection services, as permitted by paragraph ~~4200-02-10-.27~~ (4) of Rule 0400-20-10-.27, or a person providing assembly/installation/servicing, who is a staff member of the facility registered pursuant to ~~Tennessee Code Annotated, (T.C.A.) §68-202-101 et seq.~~ T.C.A. Title 68, Chapter 202 and these ~~regulations~~ rules, and who performs such inspection services or assembly/installation/servicing only for that registrant, shall not be subject to subparagraphs (b) and (c) ~~above~~ of this paragraph.
- (4) Any failure to pay an invoiced amount by the date specified on the invoice, unless qualified by ~~4200-02-10-.24 subparagraph (3)(d) above~~ of this rule, shall be deemed to constitute a violation of ~~Tennessee Code Annotated T.C.A. §§ 68-203-101 et seq.~~
- (5) Whenever there is a change in information such as address, ownership, possessor, or location of use from that declared on the last previous registration, the completion of a new Form RHS 8-4 shall be required within 10 days of the change.
- (6) Each registrant, or his estate, who permanently discontinues the use of or transfers all of his radiation machines at an installation shall notify the Division in writing within ~~sixty~~ 60 days of such action. In the event of a transfer, the notification shall include the name and address of the transferee.
- ~~(6)(7)~~ No person shall state or imply that any activity under such a registration has been approved by the Division.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-.25~~ 0400-20-10-.25 Reports.

- (1) Any person who sells, leases, transfers, assembles, reassembles, or lends radiation machines, except those exempted from registration by ~~4200-02-10-.07~~ Rule 0400-20-10-.07 shall report to the Division, within ~~thirty~~ 30 days after the end of each calendar quarter, the name and address of persons to whom they have transferred such items and the date of transfer. Persons routinely engaged in the sale, transfer, leasing, lending, assembling, or reassembling of x-ray equipment shall report each calendar quarter, including a report for calendar quarters in which no radiation machine transfer occurs. Such reports shall be held proprietary by the Division.
- (2) Each out-of-state person who brings radiation machines into the State, except those exempted in ~~4200-02-10-.07~~ Rule 0400-20-10-.07, for any temporary use shall:
 - (a) Notify the Division in writing at least ~~three~~ 3 days prior to engaging in such use. Such notification shall indicate the location, period, and type of proposed use within the State. If, for a specific case, the 3-day period would impose an undue hardship, he may, upon application to the Division obtain permission to proceed sooner;
 - (b) Register the radiation machines with this Division on Form RHS 8-4 prior to entry into the State; and
 - (c) Comply with all applicable regulations of the Division including the payment of the fee for the Class, as appropriate, contained in ~~4200-02-10-.24~~ paragraph (3) of Rule 0400-20-10-.24.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-.26~~ 0400-20-10-.26 Records.

- (1) Each person who receives radioactive material pursuant to a license issued pursuant to these rules shall keep records showing the receipt, transfer, and disposal of the radioactive material as follows:
 - (a) The licensee shall retain each record of receipt of radioactive material as long as the material is possessed and for ~~three~~ 3 years following transfer or disposal of the material.
 - (b) The licensee who transferred the material shall retain each record of transfer for ~~three~~ 3 years after each transfer, unless a specific requirement in another part of these rules dictate otherwise.
 - (c) The licensee who disposed of the material shall retain each record of disposal of radioactive material until the Division terminates each license that authorizes disposal of the material.
- (2) A licensee shall retain each record that is required by these rules or by license condition for the period specified by the appropriate rule or license condition. If a retention period is not otherwise specified by rule or license condition, the record must be retained until the Division terminates each license that authorizes the activity that is subject to the recordkeeping requirement.
- (3) Records which must be maintained pursuant to this rule may be the original or a reproduced copy. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, specifications, must include all pertinent information such as stamps, initials, and signatures. A licensee shall maintain adequate safeguards against tampering with and loss of records.
- (4) Prior to license termination, each licensee authorized to possess radioactive material with a half-life greater than 120 days, in an unsealed form, shall forward the following records to the Division:

- (a) Records of disposal of licensed material made under ~~4200-02-05-121~~ Rules 0400-20-05-121 (including burials authorized before January 28, 1981), ~~4200-02-05-122~~ 0400-20-05-122, ~~4200-02-05-123~~ 0400-20-05-123, ~~4200-02-05-124~~ 0400-20-05-124; and
 - (b) Records required by ~~4200-02-05-132~~ subparagraph (2)(d) of Rule 0400-20-05-132
- (5) If licensed activities are transferred or assigned in accordance with ~~4200-02-10-16~~ paragraph (2) of Rule 0400-20-10-16, each licensee authorized to possess radioactive material, with a half-life greater than 120 days, in an unsealed form, shall transfer the following records to the new licensee and the new licensee will be responsible for maintaining these records until the license is terminated:
- (a) Records of disposal of licensed material made under ~~4200-02-05-121~~ Rules 0400-20-05-121 (including burials authorized before January 28, 1981), ~~4200-02-05-122~~ 0400-20-05-122, ~~4200-02-05-123~~ 0400-20-05-123, ~~4200-02-05-124~~ 0400-20-05-124; and
 - (b) Records required by ~~4200-02-05-132~~ subparagraph (2)(d) of Rule 0400-20-05-132
- (6) Prior to license termination, each licensee shall forward the records required subparagraph (4)(n) of Rule ~~4200-02-10-12~~ 0400-20-10-12 to the Division.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-27~~ 0400-20-10-27 Inspections.

- (1) Each licensee or registrant shall afford the Division at all reasonable times opportunity to inspect sources of radiation, premises, facilities and activities subject of these regulations and records maintained pursuant to these regulations.
- (a) Department inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of the regulations, license, and Certified Registration to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.
 1. During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the Act, these regulations, or license or Certified Registration condition, or any unnecessary exposure to radiation or radioactive material under the licensee's or registrant's control. Any such notice in writing shall comply with paragraph (2) of this rule.
 2. The licensee or registrant or licensee's or registrant's representative may accompany Division inspectors during other phases of an inspection.
 3. The provision of ~~4200-02-10-27(1)(a)~~ part 1 of this subparagraph shall not be interpreted as authorization to disregard instructions pursuant to ~~4200-02-04-12~~ Rule 0400-20-04-12.
 - (b) If at the time of inspection, an individual has been authorized by the workers to represent them during inspections by the Division, the licensee or registrant shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.
 1. Different representative of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference

with the conduct of the inspection. However, only one worker's representative at a time may accompany the inspectors.

2. Any worker's representative shall be an employee of the licensee or registrant and should be a worker as defined in ~~1200-02-04-04(1)(rrr)~~ Rule 0400-20-04-04 and shall have received instructions as specified in ~~1200-02-04-12~~ Rule 0400-20-04-12
3. In addition to the licensee's or registrant's representative and with the approval of the licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers' representative, shall be afforded the opportunity to accompany Division inspectors during the inspection of physical working conditions.
4. The workers' representative for any area containing proprietary information shall be an individual previously authorized by the licensee or registrant to enter that area.
5. Notwithstanding the other provisions of this rule, Division inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection.

(2) Requests by Workers for Inspection.

- (a) Any worker or representative of workers who believes that a violation of ~~the Act T.C.A. §§ 68-202-201 et seq.~~, these ~~regulations~~ rules, conditions of a Certified Registration, or license conditions exists or has occurred in activities subject to these regulations with regard to radiological working conditions in which the worker is engaged, may request an inspection by registering a complaint of the alleged violation with the Commissioner, Tennessee Department of Environment and Conservation; Director, Division of Radiological Health; or Division inspectors.
 1. Any such complaint shall be in writing, shall set forth the specific grounds for the complaint and shall be signed by the worker or representative of workers.
 2. A copy of the complaint shall be provided the licensee or registrant by the Division no later than at the time of inspection except that, upon request of the worker registering such complaint, his name and the name of individuals referred to therein shall not appear in such a copy or on any record published, released or made available by the Division except for good cause shown.
- (b) If, upon receipt of such complaint, the Division determines that the complaint meets the requirements set forth in ~~1200-02-10-27(2)~~ subparagraph (a) of this paragraph and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection will be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to this paragraph need not be limited to matters referred to in the request for an inspection.
- (c) If it is determined that there are no reasonable grounds to believe that a violation exists or has occurred, the complainant shall be notified by the Division in writing.
- (d) No licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under these regulations or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself or others of any option afforded by these regulations.

(3) Inspections of radiation machines are to be conducted:

- (a) According to Class as follows:
 - CLASS I - once every ~~four~~ 4 years
 - CLASSES II and V - once every ~~two~~ 2 years
 - CLASSES III, IV, VI and VII – annually
 - (b) By personnel of the Division of Radiological Health, Tennessee Department of Environment and Conservation, or
 - (c) As provided in ~~1200-02-10-.27~~ paragraph (4) of this rule, and
 - (d) According to the same criteria and to the satisfaction of the Division and provided the appropriate Division forms are completed and submitted along with any documentation required by ~~subparagraph 1200-02-10-.24(3)~~ (e) of this paragraph, and
 - (e) By the Division of Radiological Health on a selected number of those facilities providing an inspection report as permitted by ~~1200-02-10-.27~~ paragraph (4) of this rule.
- (4) The Division will accept, as inspections for a reduced registration fee as provided for in ~~part 1200-02-10-.24 subparagraph (3)(d) of Rule 0400-20-10-24~~, inspections by individuals other than employees of the Division:
- (a) Whose inspections are satisfactory to the Division;
 - (b) Who are registered with the Division;
 - (c) Who are staff inspectors, or who have paid an annual registration fee to the Division; and
 - (d) Who meet one set of the following criteria:

	Formal Education or Certification	Plus	Experience
1.	Bachelor's degree in a physical science or mathematics		Four <u>4</u> years of applied health physics experience in a program with radiation safety problems similar to those in the program to be surveyed
2.	Bachelor's degree in a physical science or a biological science with a physical science minor and one <u>1</u> year of graduate work in health physics		Three <u>3</u> years of applied health physics experience in a program with radiation safety problems similar to those in the program to be surveyed
3.	Master's degree in health physics or radiological health		Two <u>2</u> years of applied health physics experience in a program with radiation safety problems similar to those in the program to be surveyed
4.	Doctor's degree in health physics or radiological health		One <u>1</u> year of applied health physics experience in a program with radiation safety problems similar to those in the program to be surveyed
5.	Certification by the American Board of		One <u>1</u> year of applied health physics

Health Physics or by the American Board of Radiology or be a Fellow, Canadian College of Physicists in Medicine

experience in a program with radiation safety problems similar to those in the program to be surveyed

6. ~~Two~~ 2 notarized letters of reference from persons registered to provide inspections for reduction in fees and meeting any of the above sets of criteria certifying to the individual's capabilities to perform the necessary inspections

5 years of applied health physics experience in a program with radiation safety problems similar to those in the program to be surveyed

- (5) Inspections satisfactory to the Division. The following constitute a proper inspection and must occur:
- (a) The inspection of an x-ray facility subject to registration under "State Regulations for Protection Against Radiation" shall identify the compliance status of the facility and each piece of equipment subject to registration with respect to requirements in Chapters ~~1200-02-04~~ 0400-20-04, 0400-20-05, 0400-20-06, 0400-20-08, 0400-20-09 and ~~10~~ this Chapter.
 - (b) The qualified individual performing the inspection shall record the results of the inspection on evaluation forms provided by the Division, one form for each facility plus an appropriate form, or forms, for each piece of equipment. The evaluation forms shall describe the compliance status of the facility and equipment, as it exists at the time of the inspection. The Division will accept computer-generated forms if these contain the same questions as Division forms contain.
 - (c) The qualified individual shall provide signed and dated evaluation and certification of compliance forms to the registrant promptly.
 - (d) The registrant shall submit evaluation and certification of compliance forms to the Division as set out in ~~1200-02-10-24~~ subparagraph (3)(d) of Rule 0400-20-10-24.
 - (e) A registrant whose inspection reveals an item of non-compliance shall correct the item promptly following notification by the qualified individual. The registrant shall provide appropriate documentation of the correction to the Division as set out in ~~1200-02-10-24~~ paragraph (3) of Rule 0400-20-10-24.
 - (f) If as a result of inadvertent error or excusable neglect a tube(s) is not inspected, the Commissioner or the Commissioner's designee may grant the 18 percent ~~(48%)~~ fee for all other tubes provided they were timely inspected by a qualified individual.
 - (g) For a tube that is inoperable at the time of inspection, the qualified individual shall submit a form indicating the tube was inoperable. The tube shall be inspected within 60 days of its becoming functional.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-28~~ 0400-20-10-28 Tests.

Each licensee and registrant shall perform, upon instruction from the Division, or shall permit the Division to perform, such tests as the Division may require including, but not limited to, tests of:

- (1) Sources of radiation;
- (2) Facilities wherein sources of radiation are used or stored;
- (3) Radiation detection and monitoring instruments; and

- (4) Other equipment and devices used in connection with utilization or storage of licensed or registered sources of radiation.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-.29~~ 0400-20-10-.29 Reciprocal Recognition of Licenses.

- (1) Subject to these regulations, any individual in another state who holds a specific license from the U.S. Nuclear Regulatory Commission, an Agreement State or Licensing State, and issued by the agency having primary jurisdiction, where the licensee maintains an office for directing the licensed activities and at which radiation safety records are normally maintained, may possess or use the licensed radioactive material to conduct the activities authorized by such license within this State for a period not in excess of ~~one hundred eighty~~ 180 days in any period of ~~twelve~~ 12 consecutive months and will be considered, without obtaining a specific licensing document from this Division, a licensee of this State provided that:
- (a) The out-of-state licensing document does not limit the activity authorized by such document to specified installations or locations;
 - (b) The out-of-state licensee notifies the Division in writing at least ~~three~~ 3 days prior to each entry into this State to engage in such activity. Such notification shall indicate the location, period, type of proposed possession, use and supervisor within this State, and shall be accompanied by a copy of the pertinent licensing document or shall indicate in the notification that such licensing document has previously been submitted to this Division. If for a specific case, the ~~three~~ 3 day period would impose an undue hardship, the Division may authorize such person to proceed sooner upon notification by telephone of intent to conduct the proposed activity provided that the licensee shall file in writing the information required in this paragraph within ~~three~~ 3 days of the telephone notification;
 - (c) The out-of-state licensee shall not transfer or dispose of radioactive material possessed or used under the provisions of this rule except by transfer to a person:
 - 1. Specifically licensed by the Division, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State to receive such material; or
 - 2. Exempt from the requirements for a license for such material under ~~1200-02-10-.04~~ subparagraph (1)(a) of Rule 0400-20-10-.04;
 - (d) The out-of-state licensee complies with all applicable regulations of the Division and with all the terms and conditions of his licensing document, except any such terms and conditions which may be inconsistent with applicable regulations of the Division; and
 - (e) The Division may require the out-of-state licensee to supply such other information as the Division may request.
- (2) Notwithstanding the provision of paragraph (1) ~~above of this rule~~, any person who holds a specific license issued by the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State authorizing the holder to manufacture, install, or service a device described in ~~1200-02-10-.10~~ subparagraph (2)(a) of Rule 0400-20-10-.10 within the areas subject to the jurisdiction of the licensing body is hereby granted a general license to install and service such device in this State provided that:
- (a) The device has been manufactured, labeled, installed and serviced in accordance with applicable provisions of the specific license issued to such person by the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State; and

- (b) Such person shall assure that any labels required to be affixed to the device under regulations of the authority which licensed manufacture of the device bear a statement that "Removal of this label is prohibited."
- (3) The Division may withdraw, limit, or qualify its acceptance of any specific license or equivalent licensing document issued by another agency, or any product distributed pursuant to such licensing document, upon determining that such action is necessary in order to protect the public health and safety or property.
- (4) Before radioactive materials can be used at a temporary job site within the State at any Federal facility, the jurisdictional status of the job site shall be determined. If the jurisdictional status is unknown, the Federal agency should be contacted to determine if the job site is under exclusive Federal jurisdiction.
 - (a) In areas of exclusive Federal jurisdiction, the general license is subject to all the applicable rules, regulations, orders and fees of the NRC, and
 - (b) Authorizations for use of radioactive materials at job sites under exclusive Federal jurisdiction shall be obtained from the NRC by either:
 1. Filing a NRC Form-241 in accordance with 10 CFR 150.20(b); or
 2. By applying for a specific NRC license.
- (5) Before radioactive material can be used at a temporary job site in another State, authorization shall be obtained for the State if it is an Agreement State, or from the NRC for any non-Agreement State, either by filing for reciprocity or applying for a specific license.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-30~~ 0400-20-10-30 Packaging and Transportation of Radioactive Material.

- (1) This rule establishes requirements for packaging, preparation for shipment, and transportation of radioactive material and applies to any licensee or registrant authorized by specific or general license to receive, possess, use, or transfer licensed material, if the person delivers that material to a carrier for transport, transports the material outside the site of usage as specified in the license, or transports that material on public highways. This rule does not authorize possession of licensed material.
- (2) Except as authorized in a general license or a specific license issued by the Division, or as exempted in this rule, no licensee may:
 - (a) Deliver licensed material to a carrier for transport; or
 - (b) Transport licensed material.
- (3) Any physician as defined in ~~subparagraph (1)(nn) of Rule 1200-02-04-04~~ 0400-20-04-04 is exempt from paragraph (4) of this rule ~~1200-02-10-30~~ with respect to transport by the physician of licensed material for use in the practice of medicine. However, any physician operating under this exemption must be licensed under Chapter ~~4200-02-07~~ 0400-20-07 or 10 CFR Part 35.
- (4) A licensee who, under a general or specific license, transports licensed material outside its site of authorized use or on public highways, or who delivers licensed material to a carrier for transport, shall comply with the applicable requirements of this rule and with the applicable requirements of the U.S. DOT regulations in 49 CFR Parts 107, 171 through 180, and 390 through 397, appropriate to the mode of transport.
 - (a) The licensee shall particularly note U.S. DOT regulations in the following areas:

1. Packaging: 49 CFR part 173, subparts A and B and I;
 2. Marking and labeling: 49 CFR 172, subpart D, 172.400 through 172.407, and 172.436 through 172.441 of subpart E;
 3. Placarding: 49 CFR part 172, subpart F, especially 172.500 through 172.519, 172.556 and appendices B and C;
 4. Accident reporting: 49 CFR part 171, 171.15 and 171.16;
 5. Shipping papers and emergency information: 49 CFR part 172, subparts C and G;
 6. Hazardous material employee training: 49 CFR part 172, subpart H;
 7. Hazardous material shipper/carrier registration: 49 CFR part 107, subpart G; and
 8. Security plans: 49 CFR Part 172, Subpart I.
- (b) The licensee shall also note U.S. DOT regulations pertaining to the following modes of transportation:
1. Rail: 49 CFR part 174, subparts A through D and K;
 2. Air: 49 CFR part 175;
 3. Vessel: 49 CFR part 176, subparts A through F and M; and
 4. Public highway: 49 CFR part 177 and parts 390 through 397.
- (5) If U.S. DOT regulations are not applicable to a shipment of licensed material, the licensee shall conform to the standards and requirements of the U.S. DOT specified ~~above~~ in subparagraph ~~(3)(a)~~ (4)(a) of this rule to the same extent as if the shipment or transportation were subject to U.S. DOT regulations. A request for modification, waiver or exemption from those requirements, and any notification referred to in those requirements, shall be filed with, or made to, the Director of the Division of Radiological Health at the address given in Rule ~~1200-02-04-.07~~ 0400-20-04-.07.
- (6) Exemptions.
- (a) Exemption for low-level materials.
1. A licensee is exempt from all requirements of this rule with respect to shipment or carriage of the following low-level material:
 - (i) Natural material and ores containing naturally occurring radionuclides that are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the values specified in Table A-2 of Schedule 10-6 in ~~the Appendix to Chapter 1200-02-10~~ Rule 0400-20-10-.38; and
 - (ii) Materials for which the activity concentration is not greater than the activity concentration values specified in Table A-2 of Schedule 10-6 in Rule 0400-20-10-.38, or for which the consignment activity is not greater than the limit for an exempt consignment found in Table A-2 of Schedule 10-6 in ~~the Appendix to Chapter 1200-02-10~~ Rule 0400-20-10-.38.

2. A licensee is exempt from all requirements of this rule other than paragraphs (4), (5), and (15) of ~~this rule 1200-02-10-30(3) and (4) and (10)~~, with respect to shipment or carriage of the following packages, provided the packages contain no fissile material or the fissile material exemption standards of subparagraph (6)(b) ~~or of this rule 1200-02-10-30~~ or 10 CFR 71.15 are satisfied:

- (i) A package containing no more than a Type A quantity of radioactive material;
- (ii) A package in which the only radioactive material is low specific activity (LSA) material or surface contaminated objects (SCO), provided the external radiation level at 3-meters from the unshielded material or objects does not exceed 10 mSv/h (1 rem/h); or
- (iii) A package transported within locations within the United States that contains plutonium in special form with an aggregate radioactivity not to exceed 20 curies (.74 TBq).

3. A licensee is exempt from all requirements of this rule other than paragraphs (4), (5) and (15) ~~or of this rule 1200-02-10-30~~, with respect to shipment or carriage of low-specific-activity (LSA) material in group LSA-I, or surface contaminated objects (SCO's) in group SCO-I.

(b) Exemption from classification as fissile material.

1. Fissile material meeting the requirements of at least one of the subparts (i) through (vi) of this part are exempt from classification as fissile material and from the fissile material package standards of 10 CFR 71.55 and 71.59, but are subject to all other requirements of this rule, except as noted;

- (i) Individual package containing 2 grams or less fissile material;
- (ii) Individual or bulk packaging containing 15 grams or less of fissile material provided the package has at least 200 grams of solid nonfissile material for every gram of fissile material. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass for solid nonfissile material;
- (iii) (I) Low concentrations of solid fissile material commingled with solid nonfissile material, provided that:
 - I. There is at least 2000 grams of solid nonfissile material for every gram of fissile material, and
 - II. There is no more than 180 grams of fissile material distributed within 360 kg of contiguous nonfissile material;
- (II) Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass of solid nonfissile material;
- (iv) Uranium enriched in uranium-235 to a maximum of 1 percent by weight, and with total plutonium and uranium-233 content of up to 1 percent of the mass of uranium-235, provided that the mass of any beryllium, graphite, and hydrogenous material enriched in deuterium constitutes less than 5 percent of the uranium mass;

- (v) Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of 2 percent by mass, with a total plutonium and uranium-233 content not exceeding 0.002 percent of the mass of uranium, and with a minimum nitrogen to uranium atomic ratio (N/U) of 2. The material must be contained in at least a DOT Type A package; and
 - (vi) Packages containing, individually, a total plutonium mass of not more than 1000 grams, of which not more than 20 percent by mass may consist of plutonium-239, plutonium-241, or any combination of these radionuclides.
- (7) General license: U.S. NRC-approved package.
- (a) A general license is hereby issued to any licensee of the Division to transport, or to deliver to a carrier for transport, licensed material in a package for which a license, certificate of compliance or other approval has been issued by the U.S. Nuclear Regulatory Commission.
 - (b) This general license applies only to a licensee who:
 1. Has 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;
 2. Complies with the terms and conditions of the license, certificate, or other approval, as applicable, and the applicable requirements of subparts A, G and H of 10 CFR 71;
 3. Submits in writing to the Director, Division of Radiological Health, at the address given in Rule ~~1200-02-04-07~~ 0400-20-04-07, 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; and
 4. Has submitted to the Division and received Division approval for a quality assurance program that satisfies the provisions found in subpart H of 10 CFR 71.
 - (c) This general license applies only when the package approval authorizes use of the package under this general license.
 - (d) For a Type B or fissile material package, the design of which was approved by U.S. NRC before April 1, 1996, the general license is subject to the additional restrictions in paragraph (8) of this rule.
- (8) Previously approved package.
- (a) A Type B package previously approved by U.S. NRC but not designated as B(U) or B(M) in the identification number of the U.S. NRC Certificate of Compliance, may be used under the general license in paragraph (7) of this rule with the following additional conditions:
 1. Fabrication of the packaging was satisfactorily completed by August 31, 1986, as demonstrated by application of its model number in accordance with 10 CFR 71.85(c);
 2. A package used for a shipment to a location outside the United States is subject to multilateral approval, as defined in U.S. DOT regulations at 49 CFR 173.403; and
 3. A serial number that uniquely identifies each packaging which conforms to the approved design is assigned to, and legibly and durably marked on, the outside of each packaging.

- (b) A Type B(U) package, a Type B(M) package, a low specific activity (LSA) material package or a fissile material package, previously approved by the U.S. NRC but without the designation '-85' in the identification number of the U.S. NRC Certificate of Compliance, may be used under the general license in paragraph (7) of this rule with the following additional conditions:
1. Fabrication of the package was satisfactorily completed by April 1, 1999 as demonstrated by application of its model number in accordance with 10 CFR 71.85(c);
 2. A package used for a shipment to a location outside the United States is subject to multilateral approval as defined in U.S. DOT regulations at 49 CFR 173.403; and
 3. A serial number which uniquely identifies each packaging which conforms to the approved design is assigned to and legibly and durably marked on the outside of each packaging.
- (9) General license: Use of foreign approved package.
- (a) A general license is issued to any licensee of the Division 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 U.S. DOT as meeting the applicable requirements of 49 CFR 171.12.
- (b) This general license applies only to a licensee who:
1. Has 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;
 2. Complies with the terms and conditions of the certificate and revalidation and with the applicable requirements of this rule. With respect to the quality assurance provisions of 10 CFR Part 71, the licensee is exempt from design, construction, and fabrication considerations; and
 3. Has submitted to the Division and received Division approval for a quality assurance program that satisfies the provisions found in subpart H of 10 CFR 71.
- (c) This general license applies only to shipments made to or from locations outside the United States.
- (10) General license: Fissile material
- (a) A general license is issued to any licensee of the Division or U.S. NRC to transport fissile material, or to deliver fissile material to a carrier for transport, if the material is shipped in accordance with this paragraph. The fissile material need not be contained in a package which meets the standards of 10 CFR Part 71 subparts E and F of U.S. NRC regulations; however, the material must be contained in a Type A package. The Type A package must also meet the DOT requirements of 49 CFR 173.417(a).
- (b) The general license applies only to a licensee who has submitted to the Division and received Division approval for a quality assurance program that satisfies the provisions found in Subpart H of 10 CFR 71.
- (c) The general license applies only when a package's contents:
1. Contain less than a Type A quantity of fissile material; and

2. Contain less than 500 total grams of beryllium, graphite, or hydrogenous material enriched in deuterium.
- (d) The general license applies only to packages containing fissile material that are labeled with a CSI which:
1. Has been determined in accordance with subparagraph (e) of this rule paragraph;
 2. Has a value less than or equal to 10; and
 3. For a shipment of multiple packages containing fissile material, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).
- (e) 1. The value for the CSI must be greater than or equal to the number calculated by the following equation:

$$\text{CSI} = 10 \left[\frac{\text{grams of } ^{235}\text{U}}{X} + \frac{\text{grams of } ^{233}\text{U}}{Y} + \frac{\text{grams of Pu}}{Z} \right];$$

2. The calculated CSI must be rounded up to the first decimal place;
3. The values of X, Y, and Z used in the CSI equation must be taken from Tables RHS 7-3 or 7-4, as appropriate;
4. If Table RHS 7-4 is used to obtain the value of X, then the values for the terms in the equation for uranium-233 and plutonium must be assumed to be zero; and
5. Table RHS 7-3 values for X, Y, and Z must be used to determine the CSI if:
 - (i) Uranium-233 is present in the package;
 - (ii) The mass of plutonium exceeds 1 percent of the mass of uranium-235;
 - (iii) The uranium is of unknown uranium-235 enrichment or greater than 24 weight percent enrichment; or
 - (iv) Substances having a moderating effectiveness (i.e., an average hydrogen density greater than H₂O) (e.g., certain hydrocarbon oils or plastics) are present in any form, except as polyethylene used for packing or wrapping.

Table RHS 7-3. Mass Limits for General License Packages Containing Mixed Quantities of Fissile Material or Uranium-235 of Unknown Enrichment per subparagraph (10)(e) of Rule ~~1200-02-10-30~~ 0400-20-10-30

Fissile material	Fissile material mass mixed with moderating substances having an average hydrogen density less than or equal to H ₂ O (grams)	Fissile material mass mixed with moderating substances having an average hydrogen density greater than H ₂ O ^a (grams)
²³⁵ U (X)	60	38
²³³ U (Y)	43	27
²³⁹ Pu or ²⁴¹ Pu (Z)	37	24

^a When mixtures of moderating substances are present, the lower mass limits shall be used if more than 15 percent of the moderating substance has an average hydrogen density greater than H₂O.

Table RHS 7-4 Mass Limits for General License Packages Containing Uranium-235 of Known Enrichment per subparagraph (10)(e) of Rule ~~1200-02-10-30~~ 0400-20-10-30

Uranium enrichment in weight percent of ²³⁵ U not exceeding	Fissile material mass of ²³⁵ U (X) (grams)
24	60
20	63
15	67
11	72
10	76
9.5	78
9	81
8.5	82
8	85
7.5	88
7	90
6.5	93
6	97
5.5	102
5	108
4.5	114
4	120
3.5	132
3	150
2.5	180
2	246
1.5	408
1.35	480
1	1,020
0.92	1,800

(11) General license: Plutonium-beryllium special form material.

(a) A general license is issued to any licensee of the Division or the U.S. NRC to transport fissile material in the form of plutonium-beryllium (Pu-Be) special form sealed sources, or to deliver Pu-Be sealed sources to a carrier for transport, if the material is shipped in accordance with this rule. This material need not be contained in a package which meets the standards of 10 CFR Part 71 subparts E and F; however, the material must be contained in a Type A package. The Type A package must also meet the DOT requirements of 49 CFR 173.417(a).

- (b) The general license applies only to a licensee who has submitted to the Division and received Division approval for a quality assurance program that satisfies the provisions found in Subpart H of 10 CFR 71.
- (c) The general license applies only when a package's contents:
 1. Contain no more than a Type A quantity of radioactive material; and
 2. Contain less than 1000 g of plutonium, provided that: plutonium-239, plutonium-241, or any combination of these radionuclides, constitutes less than 240 g of the total quantity of plutonium in the package.
- (d) The general license applies only to packages labeled with a CSI which:
 1. Has been determined in accordance with subparagraph (e) of this ~~rule~~ paragraph;
 2. Has a value less than or equal to 100; and
 3. For a shipment of multiple packages containing Pu-Be sealed sources, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).
- (e) 1. The value for the CSI must be greater than or equal to the number calculated by the following equation:

$$\text{CSI} = 10 \left[\frac{\text{Grams of } ^{239}\text{Pu} + \text{grams of } ^{241}\text{Pu}}{24} \right]; \text{ and}$$

- 2. The calculated CSI must be rounded up to the first decimal place.

(12) Fissile Material: Assumptions as to Unknown Properties of Fissile Material.

- (a) When the isotopic abundance, mass, concentration, degree of irradiation, degree of moderation, or other pertinent property of fissile material in any package is not known, the licensee shall package the fissile material as if the unknown properties have credible values that will cause the maximum neutron multiplication.

(13) Preliminary determinations.

- (a) Before the first use of any packaging for the shipment of licensed material:
 1. The licensee shall ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce the effectiveness of the packaging or impact compliance with the standards specified in 10 CFR 71.
 2. Where the maximum normal operating pressure will exceed 35 kPa (5 lbf/in²) gauge, the licensee shall test the containment system at an internal pressure at least 50 percent (50%) higher than the maximum normal operating pressure, to verify the capability of that system to maintain its structural integrity at that pressure; and
 3. The licensee shall conspicuously and durably mark the packaging with its model number, serial number, gross weight and a package identification number assigned by the U.S. Nuclear Regulatory Commission (U.S. NRC). Before applying the model number, the

licensee shall determine that the packaging has been fabricated in accordance with the design approved by the U.S. NRC.

(b) Reserved.

(14) Routine determinations.

(a) Before each shipment of licensed material, the licensee shall ensure that the package with its contents satisfies the applicable requirements of this rule and of the license. The licensee shall determine that:

1. The package is proper for the contents to be shipped;
2. The package is in unimpaired physical condition except for superficial defects such as marks or dents;
3. Each closure device of the packaging, including any required gasket, is properly installed, secured and free of defects;
4. Any system for containing liquid is adequately sealed and has adequate space or other specified provision for expansion of the liquid in accordance with 10 CFR 71, Subpart F;
5. Any pressure relief device is operable and set in accordance with written procedures;
6. The package has been loaded and closed in accordance with written procedures;
7. For fissile material, any moderator or neutron absorber, if required, is present and in proper condition;
8. Any structural part of the package that could be used to lift or tie down the package during transport is rendered inoperable for that purpose, unless it satisfies the design requirements of 10 CFR 71.45;
9. The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for shipment is as low as reasonably achievable and within the limits specified in U.S. DOT regulations in 49 CFR 173.443;
10. External radiation levels around the package and around the vehicle, if applicable, will not exceed the limits specified in 10 CFR 71.47 at any time during transportation; and
11. Accessible package surface temperatures will not exceed the limits specified in 10 CFR 71.43(g) at any time during transportation.

(b) Reserved.

(15) Air transport of plutonium.

(a) Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this rule or included indirectly by citation of 49 CFR Chapter I, as may be applicable, the licensee shall assure 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:

1. The plutonium is contained in a medical device designed for individual human application; or

2. The plutonium is contained in a material in which the specific activity is less than or equal to the activity concentration values for plutonium specified in Schedule 10-6. Determination of A_1 and A_2 in the ~~Appendix to Chapter 1200-02-10~~ Rule 0400-20-10-38 and in which the radioactivity is essentially uniformly distributed; or
 3. The plutonium is shipped in a single package containing no more than an A_2 quantity of plutonium in any isotope or form and is shipped in accordance with paragraphs (4) and (5) of this rule 1200-02-10-30; or
 4. The plutonium is shipped in a package specifically authorized for the shipment of plutonium by air in the Certificate of Compliance for that package issued by the U.S. Nuclear Regulatory Commission.
- (b) Nothing in subparagraph (a) of this paragraph is to be interpreted as removing or diminishing the requirements of 10 CFR 73.24.
- (c) For a shipment of plutonium by air that is subject to part (a) of this paragraph, the licensee shall, through special arrangement with the carrier, require compliance with 49 CFR 175.704, U.S. Department of Transportation regulations applicable to the air transport of plutonium.
- (16) Opening instructions.
- Before delivery of a package to a carrier for transport, the licensee shall ensure that any special instructions needed to safely open the package have been sent to, or otherwise made available to, the consignee for the consignee's use in accordance with subparagraphs (5)(a) and (b) of Rule ~~1200-02-05-115~~ 0400-20-05-115.
- (17) Records.
- (a) Each licensee shall maintain, for a period of ~~three~~ 3 years after shipment, a record of each shipment of licensed material not exempt under paragraph (6) of ~~Rule 1200-02-10-30~~ of this rule, showing where applicable:
1. Identification of the packaging by model number and serial number;
 2. Verification that there are no significant defects in the packaging, as shipped;
 3. Volume and identification of coolant;
 4. Type and quantity of licensed material in each package and the total quantity of each shipment;
 5. For each item of irradiated fissile material:
 - (i) Identification by model number and serial number;
 - (ii) Irradiation and decay history to the extent appropriate to demonstrate that its nuclear and thermal characteristics comply with license conditions; and
 - (iii) Any abnormal or unusual condition relevant to radiation safety;
 6. Date of the shipment;
 7. For fissile packages and for Type B packages, any special controls exercised;
 8. Name and address of the transferee;

9. Address to which the shipment was made; and
 10. Results of the determinations required by paragraph (14) of this rule 4200-02-10-30 and by the conditions of the package approval.
 - (b) The licensee shall make available to the Division for inspection, upon reasonable notice, all records required by this rule. Records are only valid if stamped, initialed, or signed and dated by authorized personnel or otherwise authenticated.
- (18) The licensee shall maintain sufficient written records to furnish evidence of the quality of packaging. The records to be maintained include results of the determinations required by paragraph (13) of this rule 4200-02-10-30; 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 shall identify the inspector or data recorder, the type of observation, the results, the acceptability and the action taken in connection with any deficiencies noted. The records shall be retained for ~~three~~ 3 years after the life of the packaging to which they apply.
- (19) Inspection and tests.
- In addition to the requirements in paragraph (1) of ~~4200-02-10-27~~ Rule 0400-20-10-27 and Rule ~~4200-02-10-28~~ 0400-20-10-28, the licensee shall notify the Director, Division of Radiological Health, at the address given in Rule ~~4200-02-04-07~~ 0400-20-10-07, at least 45 days before fabrication of a package to be used for the shipment of licensed material having a decay heat load in excess of 5 kW or with a maximum normal operating pressure in excess of 103 kPa (15 lbf/in²) gauge.
- (20) Reports.
- The licensee shall report to the Director, Division of Radiological Health, 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; or
 - (c) Instances in which the conditions of approval in the certificate of compliance were not observed in making a shipment.
- (21) Advance notification of shipment of irradiated reactor fuel and nuclear waste.
- (a) As specified in subparagraphs (b), (c) and (d) of this paragraph, each licensee shall provide advance notification to the governor of ~~a~~ a state, or the governor's designee, and to the Director, Division of Radiological Health, of the shipment of licensed material through or across the boundary of the State, 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.
 - (b) Advance notification is required under this ~~section~~ paragraph for shipments of irradiated reactor fuel in quantities less than that subject to advance notification requirements of 10 CFR 73.37(f). Advance notification is also required under this ~~section~~ paragraph for shipment of licensed material, other than irradiated fuel, meeting the following three conditions:
 1. The licensed material is required by 10 CFR 71 to be in Type B packaging for transportation;

2. The licensed material is being transported to or across the State boundary en route to a disposal facility or to a collection point for transport to a disposal facility; and
 3. The quantity of licensed material in a single package exceeds the least of the following:
 - (i) 3000 times the A_1 value of the radionuclides as specified in Schedule 10-6 in Rule 0400-20-10-.38, Table A-1 for special form radioactive material;
 - (ii) 3000 times the A_2 value of the radionuclides as specified in Schedule 10-6 in Rule 0400-20-10-.38, Table A-1 for normal form radioactive material; or
 - (iii) 1000 TBq (27,000 Ci).
- (c) Procedures for submitting advance notification.
1. The notification shall be made in writing to the office of each appropriate governor or governor's designee and to the Director, Division of Radiological Health.
 2. A notification delivered by mail shall be postmarked at least ~~seven~~ 7 days before the beginning of the ~~seven~~ 7-day period during which departure of the shipment is estimated to occur.
 3. A notification delivered by any other means than mail shall reach the office of the governor, or of the governor's designee, and of the Director, Division of Radiological Health, at least ~~four~~ 4 days before the beginning of the ~~seven~~ 7-day period during which departure of the shipment is estimated to occur.
 - (i) A list of the names and mailing addresses of the governors' designees receiving advance notification of transportation of nuclear waste was published in the Federal Register on June 30, 1995 (60 FR 34306).
 - (ii) The list will be published annually in the Federal Register on or about June 30 to reflect any changes in information.
 - (iii) A list of the names and mailing addresses of the governors' designees is available on request from the Director, Office of State Programs, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.
 - (iv) The licensee shall retain a copy of the notification as a record for ~~three~~ 3 years.
- (d) Information to be furnished in advance notification of shipment. Each advance notification of shipment of irradiated reactor fuel or nuclear waste shall contain the following information:
1. The name, address and telephone number of the shipper, carrier and receiver of the irradiated reactor fuel or nuclear waste shipment;
 2. A description of the irradiated reactor fuel or nuclear waste contained in the shipment, as specified in the regulations of U.S. DOT in 49 CFR 172.202 and 172.203(d);
 3. The point of origin of the shipment and the ~~seven~~ 7-day period during which departure of the shipment is estimated to occur;
 4. The ~~seven~~ 7-day period during which arrival of the shipment at the State's boundaries is estimated to occur;

5. The destination of the shipment and the ~~seven~~ 7-day period during which arrival of the shipment is estimated to occur; and
6. A point of contact, with a telephone number, for current shipment information.

(e) Revision notice.

A licensee who finds that schedule information previously furnished to the governor, or governor's designee, and to the Director, Division of Radiological Health, in accordance with this ~~section~~ paragraph, will not be met, shall telephone a responsible individual in the office of the governor of the State, or of the governor's designee, and of the Division of Radiological Health and inform those individuals of the extent of the delay beyond the schedule originally reported. The licensee shall maintain a record of the name of the individual contacted for ~~three~~ 3 years.

(f) Cancellation notice.

1. Each licensee who cancels an irradiated reactor fuel or nuclear waste shipment for which advance notification has been sent shall send a cancellation notice to the governor of each State, or to the governor's designee, previously notified, and to the Director, Division of Radiological Health.
2. The licensee shall state in the notice that it is a cancellation and identify the advance notification that is being canceled. The licensee shall retain a copy of the notice as a record for ~~three~~ 3 years.

(22) Quality Assurance

(a) Quality Assurance Requirements.

1. This subparagraph describes quality assurance requirements applying to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of components of packaging that are important to safety. As used in this paragraph, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that a system or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to control of the physical characteristics and quality of the material or component to predetermined requirements. The licensee, certificate holder, and applicant for a CoC are responsible for the quality assurance requirements as they apply to design, fabrication, testing, and modification of packaging. Each licensee is responsible for the quality assurance provision which applies to its use of a packaging for the shipment of licensed material subject to this paragraph.

2. Establishment of program.

Each licensee, certificate holder, and applicant for a CoC shall establish, maintain, and execute a quality assurance program satisfying each of the applicable criteria of 10 CFR 71.101 through 71.137 and satisfying any specific provisions that are applicable to the licensee's activities including procurement of packaging. The licensee, certificate holder, and applicant for a CoC shall execute the applicable criteria in a graded approach to an extent that is commensurate with the quality assurance requirement's importance to safety.

3. Approval of program.

Before the use of any package for the shipment of licensed material subject to this paragraph, each licensee shall obtain Division approval of its quality assurance program

and file a description of its quality assurance program, including a discussion of which requirements of this paragraph are applicable and how they will be satisfied.

4. Radiography containers.

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 subparagraph (8)(b) of Rule ~~1200-02-08-04~~ 0400-20-08-04 or equivalent Nuclear Regulatory Commission, or Agreement State requirement, is deemed to satisfy the requirements of ~~parts~~ part (7)(b)4 of this rule and (22)(a) part 2 of Rule 1200-02-10-30 of this subparagraph.

(b) Quality assurance organization.

1. A licensee¹⁴, certificate holder, and applicant for a CoC shall be responsible for the establishment and execution of the quality assurance program. The licensee, certificate holder, and applicant for a CoC 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 shall retain responsibility for the program. These activities include performing the functions associated with attaining quality objectives and the quality assurance functions.
2. The quality assurance functions are:
 - (i) Assuring that an appropriate quality assurance program is established and effectively executed; and
 - (ii) Verifying, by procedures such as checking, auditing, and inspection, that activities affecting the functions that are important to safety have been correctly performed.
3. The persons and organizations performing quality assurance functions must have sufficient authority and organizational freedom to:
 - (i) Identify quality problems;
 - (ii) Initiate, recommend, or provide solutions; and
 - (iii) Verify implementation of solutions.

(c) Quality assurance program.

1. A licensee, certificate holder, and applicant for a CoC shall establish, at the earliest practicable time consistent with the schedule for accomplishing the activities, a quality assurance program that complies with the requirements of 10 CFR 71.101 through 71.137. The licensee, certificate holder, and applicant for a CoC shall document the quality assurance program by written procedures or instructions and shall carry out the program in accordance with those procedures throughout the period during which the packaging is used. The licensee, certificate holder, and applicant for a CoC shall identify the material and components to be covered by the quality assurance program, the major

¹⁴ While the term "licensee" is used in these criteria, the requirements are applicable to whatever design, fabrication, assembly, and testing of the package is accomplished with respect to a package before the time a package approval is issued.

organizations participating in the program, and the designated functions of these organizations.

2. A licensee, certificate holder, and applicant for a CoC, through its quality assurance program, shall 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 assure conformance to the approved design of each individual package used for the shipment of radioactive material. The licensee, certificate holder, and applicant for a CoC shall assure 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, certificate holder, and applicant for a CoC shall 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.
3. A licensee, certificate holder, and applicant for a CoC shall 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:
 - (i) The impact of malfunction or failure of the item to safety;
 - (ii) The design and fabrication complexity or uniqueness of the item;
 - (iii) The need for special controls and surveillance over processes and equipment;
 - (iv) The degree to which functional compliance can be demonstrated by inspection or test; and
 - (v) The quality history and degree of standardization of the item.
4. A licensee, certificate holder, and applicant for a CoC shall provide for indoctrination and training of personnel performing activities affecting quality, as necessary to assure that suitable proficiency is achieved and maintained. The licensee, certificate holder, and applicant for a CoC shall 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 they are executing.

(d) Handling, storage, and shipping control.

The licensee, certificate holder, and applicant for a CoC shall establish measures to control, in accordance with 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.

(e) Inspection, test, and operating status.

1. A licensee, a certificate holder, and an applicant for a CoC shall 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.

2. A licensee shall establish measures to identify the operating status of components of the packaging, such as tagging valves and switches, to prevent inadvertent operation.

(f) Nonconforming materials, parts, or components.

A licensee, certificate holder, and applicant for a CoC shall establish measures to control materials, parts, or components that do not conform to the licensee's requirements to prevent their 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 in accordance with documented procedures.

(g) Corrective action.

A licensee, certificate holder, and applicant for a CoC shall establish measures to assure 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 adverse to quality, the measures must assure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action taken must be documented and reported to appropriate levels of management.

(h) Quality assurance records.

A licensee, certificate holder, and applicant for a CoC shall maintain sufficient written records to describe the activities affecting quality. The records must include the instructions, procedures, and drawings required by 10 CFR 71.111 to prescribe quality assurance activities and must include closely related specifications such as required qualifications of personnel, procedures, and equipment. The records must include the instructions or procedures which establish a records retention program that is consistent with applicable regulations and designates factors such as duration, location, and assigned responsibility. The licensee, certificate holder, and applicant for a CoC shall retain these records for 3 years beyond the date when the licensee, certificate holder, and applicant for a CoC last engage in the activity for which the quality assurance program was developed. If any portion of the written procedures or instructions is superseded, the licensee, certificate holder, and applicant for a CoC shall retain the superseded material for 3 years after it is superseded.

(i) Audits.

A licensee, a certificate holder, and an applicant for a CoC shall carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program. The audits must be performed in accordance with written procedures or checklists by appropriately trained personnel not having 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 re-audit of deficient areas, must be taken where indicated.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-.34~~ 0400-20-10-.31 Fees for Licenses.

(1) A fee shall be assessed and collected on the application for and annual maintenance of licenses regarding radioactive materials, as follows:

(a) Application filing fees from applicants for licenses to use or possess radioactive materials or any other activity authorized under this Chapter that requires a license from the Department.

- (b) Annual maintenance fees from licensees or persons required to possess a license under this Chapter, including reciprocal activity under ~~1200-02-10-29~~ Rule 0400-20-10-29.
- (2) The application filing fees shall be the same amount as the annual maintenance fees set forth in paragraphs (6) through (19) of this rule. A radioactive material license application will not be considered for completeness unless the application filing fee has been paid in full. Within 15 days of receipt of an application, an invoice for the fee will be prepared and mailed to the applicant. The application filing fee is not refundable, except as specified in ~~Public Chapter 417, Acts of 1994~~ T.C.A. § 68-203-103. Applicants for licenses greater than Category 8 shall pay the application fee annually until such time as the license is issued or denied. (An application filing fee shall be required when a licensee applies for a license modification to change to a higher numbered category, in which case the application fee will be the amount of the proposed new Category. The application filing fee shall serve as full payment of fees for the balance of the calendar year in which the license is issued.)
 - (3) If a license authorizes activities under more than one Category, the application and annual maintenance fee shall be the cumulative total for each applicable category under which the license is issued.
 - (4) The annual maintenance fees, based on the categories in paragraphs (6) through (19) of this rule shall be payable to the Division of Radiological Health by check made payable to "Treasurer State of Tennessee" by February 17 of each year, as indicated on the annual invoice, until the license is terminated in accordance with these regulations.
 - (a) Provided that the licensee has demonstrated to the satisfaction of the Department that all of the requirements concerning disposal of radioactive material and the decontamination of facilities are met, the termination of the license is administratively accomplished by using one of the following:
 1. As requested by the licensee;
 2. By the Department for cause; or
 3. In accordance with these regulations.
 - (b) The failure to acquire radioactive material or the disposal of radioactive material without notifying the Department and requesting termination in writing does not constitute termination of the license.
- (5) Complete Applications
 - (a) For the purpose of determining whether or not the Division has acted in the time frame established to process applications set forth in ~~(5)~~ subparagraph (e) of this paragraph, the evaluation period shall not begin until a complete application has been filed in the Division of Radiological Health Central Office. All items on the application form shall be completed in sufficient detail to allow the Division to determine that the applicant's equipment, facilities and radiation protection program are adequate to protect health and minimize danger to life and property.
 - (b) The Division shall denote the date that all applications for radioactive material license are received in its Nashville office.
 - (c) Upon receipt of an application, the Division must examine it to insure that it is complete and advise the applicant in writing of its findings via certified mail. ~~Sixty~~ 60 days will be allowed for the initial and each subsequent review per ~~(e)~~ part 3 of this Rule subparagraph.

1. If an application is determined to be incomplete, the Division must notify the applicant in writing via certified mail of the finding with a brief explanation of the deficiencies. The application filing fee shall be retained by the Division.
 2. After receiving notice from the Division that the application was incomplete, the applicant shall have ~~one hundred eighty~~ 180 calendar days to correct the deficiencies. If properly corrected, the application will be processed and no additional application fee is required, except for the possibility of those above Category 8. If the deficiencies are not corrected within the 180 day correction period, the fee will be forfeited in its entirety to the Division with no further action taken on the application by the Division. If the applicant re-applies, a new application fee must be paid in full.
 3. Upon receipt of a corrected application revised pursuant to part 1 or 2 of this subparagraph ~~(e)~~, the Division shall re-evaluate the application and notify the applicant of its finding as to whether or not the deficiencies in the application have been completed. The same procedure to notify an applicant as to whether or not the application is complete will follow the requirements specified by this subparagraph, with the exception being that the ~~one hundred eighty~~ 180 day correction period begins from the receipt of the initial application - not receipt of the revised application.
 4. Any person possessing licensable quantities of unlicensed radioactive material during the review of an application for a license for the radioactive material shall be in violation of ~~4200-02-10-02~~ Rule 0400-20-10-02.
- (d) Revisions to an application, to reflect changes in radioactive material or its use, will be accepted by the Division during the application processing period. However, notwithstanding ~~(5)~~ subparagraph (e) of this Rule paragraph, the deadline for evaluation as to issuance of a license will restart upon each and every revision.
- (e) The Division shall make a decision to issue or deny a request for a new radioactive material license, except Category 12, and notify the applicant of that decision in no more than 365 days after receipt of a complete application, unless the Division has requested technical assistance in the review of the application from the Nuclear Regulatory Commission.
- (6) CATEGORY GL \$ 150
- Any person processing radioactive material, under the terms of any general license issued under these regulations, in a form or device on which a test for leakage of radioactive material is required.
- (7) CATEGORY 1 \$ 300
- A specific license for source material used exclusively for shielding radiation.
- (8) CATEGORY 2 \$ 600
- (a) Reserved.
- (b) The application, use or possession of radioactive material as chromatography sources or gauges not requiring assignment to another category.
- (c) The application, use or possession of radioactive material for "in vitro" use only, total quantity not to exceed 200 microcuries.

- (d) Any person who packages or containerizes, loads transport vehicles or ships radioactive materials to a licensed disposal/processing facility in Tennessee. In addition to application and annual maintenance fees, there is also a levied fee of ~~two~~ 2 cents per pound (\$.02/lb) on all items contaminated or potentially contaminated with radioactive material or on low-level radioactive waste received at a processing, storage, disposal or refurbishing facility in Tennessee.

Notwithstanding the requirements of this paragraph and Rule ~~1200-02-40-.32~~ 0400-20-10-.32, licensees with multiple sites within the state will be levied only one fee if items are moved directly from one site to another.

The operator of the disposal/processing facility shall collect the fee of ~~two~~ 2 cents per pound (\$.02/lb). For each calendar month, he shall remit the total of fees collected for the month to the Division of Radiological Health by the 25th day of the following month.

- (e) The application, use or possession of radioactive material for the calibration for hire of radiation detection, monitoring and measuring instruments.
- (f) The performance for hire of leak tests on sealed sources of radioactive material.

(9) CATEGORY 3 \$ 900

- (a) The application, use or possession of radioactive material, unless specific to a higher numbered category, by an academic institution, but does not include licenses authorizing all radioisotopes with atomic number 3 through 83.
- (b) The possession and use of radioactive material for civil defense activities.
- (c) The application, use or possession of radioactive material by a medical institution or physicians for use in radiopharmaceuticals for the diagnosis or therapy of humans.
- (d) Reserved.
- (e) Reserved.
- (f) Reserved.
- (g) The application, use or possession of radioactive material for demonstration or training purposes.
- (h) The application, use or possession of radioactive material for "in vitro" use only, total quantity exceeding 200 microcuries.
- (i) The use of sealed sources for soil and/or construction materials testing at temporary job-sites by licensees with licensed authorization for no more than 2 devices.

- (j) The use of radioactive material as chromatography sources at temporary job-sites by licensees with licensed authorization for no more than 2 devices.
 - (k) The use of gauging and measuring devices at temporary job-sites by licensees with licensed authorization for no more than 2 devices.
- (10) CATEGORY 4 \$ 1,500
- (a) The application, use or possession of radioactive material by a medical institution or physicians for interstitial, intracavitary or superficial treatment of humans using sealed sources, seeds or wires.
 - (b) The application, use or possession of radioactive material in sealed sources for irradiation of materials in which the source is not removed from its shield (self-contained irradiations).
 - (c) The application, use or possession or radioactive material for analytical testing purposes.
- (11) CATEGORY 5 \$ 2,100
- (a) The use of radioactive material in research and development, manufacturing, testing, processing and assembling of products. This group includes the use of source material in the manufacture of items such as mantles, alloys, gases, liquids, metals, ceramics, glass or photographic products.
 - (b) The use of radioactive material in a process that incorporates that material into a product in exempt concentrations.
 - (c) The possession and use of radioactive material in curie quantities in a number of sources in gauges and gauging applications that require frequent changes and therefore frequent review of the program to ensure that the hazard potential does not exceed the scope of the radiation safety program.
 - (d) The use of a single radioactive material in the fabrication of sealed sources or ampoules.
 - (e) The receipt of prepackaged radioactive material waste from other persons by a nuclear waste handler for storage for less than ~~three~~ 3 months before transfer only to persons licensed to receive or dispose of the material.
 - (f) The use of sealed sources for soil and/or construction materials testing at temporary job-sites by licensees with licensed authorization for more than ~~two~~ 2 devices.
 - (g) The use of radioactive material as chromatography sources at temporary job-sites by licensees with licensed authorization for more than ~~two~~ 2 devices.
 - (h) The use of gauging and measuring devices at temporary job-sites by licensees with licensed authorization for more than ~~two~~ 2 devices.

- (i) The application, use or possession of radioactive material by a medical institution or physicians for the treatment of humans with sealed sources contained in teletherapy devices.
 - (j) The application, use or possession of radioactive material by a veterinarian for the treatment of animals using sealed sources, seeds or wires.
- (12) CATEGORY 6 \$ 6,000
- (a) The application, use or possession of radioactive material including source and/or special nuclear material in unsealed form in less than multicurie quantities for use in the fabrication of sealed sources without regard to amount of contained radioactivity.
 - (b) The manufacture of devices and/or sources that require in-depth review before approval by the Division. Each device and/or source reviewed shall be subject to this fee.
 - (c) The preparation, use or distribution of radiopharmaceuticals to locations other than the licensee's address for use in medical diagnosis or therapy.
 - (d) The use of radiography (the examination of the structure of materials by nondestructive methods using radioactive material) on the licensee's premises in a permanent shielded facility or temporary job-sites.
 - (e) The possession and use of radioactive material by academic and medical institutions under a license authorizing all radioisotopes with atomic numbers 3 through 83.
 - (f) Reserved.
 - (g) The application of radioactive material to soil, water, air, plants and animals, if the application involves an actual or potential release in or to unrestricted areas.
 - (h) The possession, use and distribution of radioactive material at one or more satellite facilities, or the possession and use of radioactive material at one or more satellite facilities, by medical institutions.
 - (i) The application, use or possession of radioactive material by a medical institution or physicians for research using humans and/or animals.
- (13) CATEGORY 7 \$ 4,000
- (a) Reserved.
 - (b) Reserved.
 - (c) The application, use or possession of radioactive material for well logging well surveys or tracer studies.
- (14) CATEGORY 8 \$ 11,250
- (a) The receipt of radioactive material waste from other persons by a nuclear waste handler, for the purpose of packaging or repackaging the material

prior to transfer only to persons licensed to receive or dispose of the material.

- (b) The commercial collection, laundering or dry cleaning of wearing apparel that is contaminated with radioactive material.

(15) CATEGORY 9 \$ 15,000

- (a) The possession of radioactive material or equipment contaminated or potentially contaminated with radioactive material as a result of operations involving the recovery of an element, compound or mixture from ores not subject to licensure because of the radioactive material content of the ore.

- (b) Facilities that possess radioactive material as a result of operations (not directly involving radioactive decontamination activities) involving recovery of materials or other manufacturing processes (not directly manufacturing radioactive items or products).

(16) CATEGORY 10 \$ 22,500

- (a) Facilities storing radioactive material, contaminated equipment and/or potentially contaminated equipment for transfer to authorized recipients as a service to the nuclear industry.

- (b) Possession and refurbishment of contaminated equipment and/or potentially contaminated equipment that has been used at nuclear power plants.

(17) CATEGORY 11 \$ 30,000

- (a) The collection, transfer, sorting and/or brokerage of radioactive material as sealed source, residue, product or as material in or on equipment; and/or

The decontamination of products and/or equipment containing radioactive material and/or contaminated with radioactive material; and/or

The possession, storage and incineration of radioactive material or items contaminated with radioactive materials.

- (b) On site possession and storage of radioactive material and/or equipment contaminated with radioactive material as a result of operations involving the recovery of an element, compound or mixture from ores subject to licensure because of the radioactive material content of the ore or concentration of the radioactive material during the processing of the ore.

- (c) Facilities involved in the manufacture of product lines containing radioactive material in the manufactured product.

- (d) Possession of radioactive material for processing. This material may exist in ores, concentrates, compounds or metals.

- (e) The possession of multicuries quantities of unsealed radioactive material either as waste or for further processing and/or conversion into specific marketable products.
 - (f) Operations involving the fabrication of sealed sources or manufacture of compounds for distribution to other specific or general licensees.
 - (g) The possession and use of radioactive material in a sealed source for irradiation of materials in which the source is exposed for irradiation purposes (non self-contained irradiations).
- (18) CATEGORY 12 \$ 375,000
- (a) The application for and/or operation of a low-level radioactive waste disposal facility.
 - (b) The maximum length of reviewing time (the period of time when there are no outstanding unanswered questions) after receipt of a new application and the appropriate fee for a Category 12 specific license and the issuance of a license is 60 months.

(19) CATEGORY 13 At least \$ 150 not greater than \$ 375,000

The application, use or possession of radioactive material for uses or procedures not specifically included in any other category.

The fee shall be determined on a case-by-case basis.

The determination shall be based on an analysis of the hazard, the scope of the difficulty encountered in the review process and the specifics of the activity pursuant to the categories established above.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-.32~~ 0400-20-10-.32 Licensing of Shippers of Radioactive Material into or Within Tennessee.

- (1) This rule applies to any shipper who transports or offers for transport into or within Tennessee on public waterways, roadways, railways or other transportation facilities upon which United States Department of Transportation (USDOT) regulations are applicable, any radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities for packaging, repackaging, processing, refurbishing, storage pending disposal or disposal.
- (2) All persons subject to the provisions of this rule shall comply with all applicable provisions of the USDOT Regulations (49 CFR) of October 1, 1990, as amended, the U.S. Nuclear Regulatory Commission (NRC) Regulations (10 CFR) of November 30, 1988, as amended, and any disposal/processing facility radioactive material license requirements with special emphasis regarding the packaging, transportation, disposal, storage pending disposal or delivery of radioactive material.
- (3) Definitions used in this rule.
 - (a) "Carrier" means any person who transports radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities.
 - (b) "Disposal" means isolation of radioactive waste from the biosphere.

- (c) "Disposal/Processing Facility" means any facility located within Tennessee that accepts radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities for packaging, repackaging, processing, refurbishing, storage pending disposal or disposal.
 - (d) (Reserved)
 - (e) (Reserved)
 - (f) "License for delivery" means an authorization issued by the Division to any shipper of radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities to transport such radioactive material or offer such material for transport to a disposal/processing facility.
 - (g) "Shipper" means any person, whether a resident of Tennessee or a non-resident:
 1. Who transfers radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities to a carrier for transport;
 2. Who transports his own radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities;
 3. Who transports radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities he has packaged, repackaged, processed or stored pending disposal for another person; or
 4. Who transfers radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities to another person if such materials are transported into or within the state.
 - (h) "Transport" means the movement of radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities into or within the State of Tennessee on waterways, roadways, railways or other transportation facilities upon which USDOT regulations are applicable.
- (4) Licensing for Delivery.
- (a) Before any shipper transports or causes to be transported radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities to a disposal/processing facility within the State for subsequent processing, he shall obtain a license for delivery of such materials from the Division. An application for a license for delivery shall be submitted on Division Form RHS-30, together with any necessary fee, to the Division at the address in Rule ~~4200-02-04-.07~~ 0400-20-04-.07. The check for payment of the fee is to be made payable to "Treasurer: State of Tennessee."
 - (b) Before a license for delivery shall be issued, the shipper must deposit and maintain with the Division an acceptable form of financial assurance in the amount of ~~Five Hundred Thousand Dollars~~ \$500,000; or, provide to the Division satisfactory evidence of liability insurance.
 1. For purposes of this paragraph, liability insurance shall mean coverage of ~~Five Hundred Thousand Dollars~~ \$500,000 per occurrence and ~~one Million Dollars~~ \$1,000,000 aggregate, or as otherwise provided by State law.

2. Any insurance carried pursuant to Section 2210 of Title 42 of the United States Code and U.S. NRC Regulations (10 CFR Part 140) of November 30, 1988, as amended shall be sufficient to meet the requirements of ~~1200-02-10-32(4)(b)~~ this subparagraph.
 3. Liability insurance shall be specific to the packaging, transportation, disposal, storage and delivery of radioactive waste.
 4. Shippers maintaining liability insurance for the purpose of this paragraph may provide to the Division a certificate of insurance from their insurer indicating the policy number, limits of liability, policy date and specific coverage for packaging, transportation, disposal, storage pending disposal and delivery of radioactive materials.
 5. A cash or corporate surety bond previously posted will be returned to the shipper upon notification to the Division in writing of his intention to cease shipments of radioactive waste into or within the State. Such bond will be returned after the last such shipment is accepted safely at its destination.
- (c) Each license for delivery application shall include a certification to the Division that the shipper will comply fully with all applicable State and Federal laws, administrative rules and regulations, licenses, or license conditions of the disposal/processing facility regarding the packaging, transportation, storage pending disposal, disposal and delivery of radioactive materials.
- (d) Each license for delivery application shall include a certification that the shipper will hold the State of Tennessee harmless for all claims, actions or proceedings in law or equity arising out of radiological injury or damage to persons or property occurring during the transportation of its radioactive waste into or within the State including all costs of defending the same; provided, however, that nothing contained herein shall be construed as a waiver of the State's sovereign immunity; and, further provided that agencies of the State of Tennessee shall not be subject to the requirements of ~~(4) subparagraph (b) of this rule paragraph~~.
- (5) Disposal/processing facility operator.
- (a) Owners and operators of disposal/processing facilities shall permanently record, and report to the Division within ~~twenty-four~~ 24 hours after discovery, all conditions in violation of the requirement of this rule discovered as a result of inspections required by any license under which the facility is operated. In addition, owners and operators of disposal/processing facilities shall record all violations of these regulations and license conditions and maintain the record for inspection by the Division.
 - (b) Prior to the receipt of radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities at a disposal/processing facility in Tennessee, the owners and operators of such facility shall notify each shipper of any special requirements, if any, in effect regarding the packaging, transportation, storage pending disposal, disposal or delivery of such wastes at that facility.
 - (c) No owner or operator of a disposal/processing facility located within this State shall accept radioactive waste and/or items contaminated or potentially contaminated with licensable quantities of radioactive material or from licensable activities for packaging, repackaging, processing, refurbishing, storage pending disposal or disposal unless the shipper of such waste has a valid license for delivery issued pursuant to this rule.
 - (d) The owner or operator of a disposal/processing facility shall, along with the remittance of the fee collected pursuant to ~~1200-02-10-31~~ subparagraph (8)(d) of Rule 0400-20-10-31, submit a listing containing the name and address of each shipper and the volume and poundage from each shipper for the calendar month.

(6) Penalties.

All shippers shall be subject to fees and Civil Penalties as authorized and specified in Tennessee Code Annotated ~~68-23-212~~ T.C.A. § ~~68-202-212~~ and other pertinent regulations rules of the Division.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-33~~ 0400-20-10-33 Reserved.

(Note: The following has been moved to the Appendix to this Chapter (~~1200-02-10-38~~ Rule 0400-20-10-38):

- Schedule RHS 8-3 Exempt Quantities
- Schedule RHS 8-4 Exempt Concentrations
- Schedule RHS 8-5 General Licensing of Certain Named Devices)

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-34~~ 0400-20-10-34 Supplemental Fees for Calendar Year 2001 Reserved

~~(1) Purpose.~~

~~Adequate funds are required to facilitate the proper administration of The Radiological Health Service Act and The Medical Radiation Inspection Safety Act. Failure to properly administer these acts threatens the health and safety of the citizens of the state. Operating revenue for the administration of these acts is collected on a calendar year basis. Projected revenue needs of the Division in 2001 cannot be met by current registration and licensing fees. Rulemaking to increase 2001 fees cannot be completed prior to the first assessment date, January 1, 2001. Therefore, one time supplemental fees are hereby established to provide the Division with additional revenue during Calendar Year 2001. Division invoices will establish due dates for payment these supplemental fees, except that after the effective date of this Rule the operator of a disposal/processing facility shall begin to collect and submit the base fee (\$0.01/lb) required by 1200-02-10-31(8)(d) and the supplemental fee (\$0.005/lb) together.~~

~~(2) Supplemental Fees Schedules.~~

~~(a) In addition to the fees established in paragraph (3) of Rule 1200-02-10-24 Registration, persons subject to registration anytime during Calendar Year 2001 shall pay a supplemental fee to be determined according to Schedule I of this paragraph:~~

SCHEDULE I

Class I Equipment	\$ 10 per tube
Class II Equipment	\$ 40 per tube
Class III Equipment	\$ 20 per tube
Class IV Equipment	\$ 50 per tube
Class V Equipment	\$ 200 per tube
Class VI Equipment	\$ 300 per tube
Class VII Equipment	\$ 500 per tube

~~plus, for each accelerator initial review, a supplemental fee of \$ 125 per maximum nominal rated MeV (total supplemental initial review fee not to exceed \$ 50,000)~~

~~A person providing inspection services under paragraph 1200-02-10-27(4), except as provided by paragraph 1200-02-10-24(3)(c). \$ 200~~

~~(b) In addition to the fees established in paragraphs (6) through (19) of Rule 1200-02-10-31 Fees for Licenses, persons subject to licensure anytime during Calendar Year 2001 shall pay a supplemental fee to be determined according to Schedule II of this paragraph:~~

~~SCHEDULE II~~

~~Category GL \$ 50~~

~~Category 1 \$ 100~~

~~Category 2 \$ 200~~

~~Category 2d In addition to the supplemental fee for Category 2, the operator of a disposal/processing facility shall collect and remit a supplemental fee, on items contaminated or potentially contaminated with radioactive material or on low-level radioactive waste received, of 0.005/lb~~

~~Notwithstanding the requirements of paragraph 1200-02-10-31 (8) and Rule 1200-02-10-32, licensees with multiple sites within the state will be levied the supplemental fee only once on items moved directly from one site to another.~~

~~Category 3 \$ 300~~

~~Category 4 \$ 500~~

~~Category 5 \$ 700~~

~~Category 6 \$ 2,000~~

~~Category 7 \$ 1,000~~

~~Category 8 \$ 3,750~~

~~Category 9 \$ 5,000~~

~~Category 10 \$ 7,500~~

~~Category 11 \$ 10,000~~

~~Category 12 \$ 125,000~~

~~Category 13 At least \$50 not greater than \$ 125,000~~

~~The category 13 supplemental fee shall be determined on a case-by-case basis. The determination shall be based on an analysis of the hazard, the scope of the difficulty encountered in the review process and the specifics of the activity, following the categories established in paragraphs (6) through (19) of Rule 1200-02-10-31.~~

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-35~~ 0400-20-10-35 Reserved.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~4200-02-10-36~~ 0400-20-10-36 Radiological Criteria for License Termination.

(1) General provisions and scope.

- (a) The criteria in this rule apply to the decommissioning of facilities licensed under this Chapter ~~4200-02-10~~ and Chapters ~~4200-02-07~~ 0400-20-07, ~~4200-02-08~~ 0400-20-08, ~~4200-02-09~~ 0400-20-09, ~~4200-02-11~~ 0400-20-11 and ~~4200-02-12~~ 0400-20-12. For low-level waste disposal facilities (Chapter ~~4200-02-11~~ 0400-20-11), the criteria apply only to ancillary surface facilities that support radioactive waste disposal activities.
- (b) Reserved.
- (c) After a site has been decommissioned and the license terminated in accordance with the criteria in this rule, the Division will require additional cleanup if, based on new information, it determines that the criteria of this rule were not met and residual radioactivity remaining at the site could result in a significant threat to public health and safety.
- (d) When calculating TEDE to the average member of the critical group the licensee shall determine the peak annual TEDE dose expected within the first 1,000 years after decommissioning.

(2) Radiological criteria for unrestricted use.

A site will be considered acceptable for unrestricted use if:

- (a) The residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and
- (b) The residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels that are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, potentially expected to result from decontamination and waste disposal.

(3) Criteria for license termination under restricted conditions.

A site will be considered acceptable for license termination under restricted conditions if:

- (a) A licensee can demonstrate that further reductions in residual radioactivity necessary to comply with the provisions of paragraph ~~4200-02-10-36~~ (2) of this rule:
 - 1. Would result in net public or environmental harm or
 - 2. Were not being made because the residual levels associated with restricted conditions are ALARA. Determination of the levels that are ALARA must take into account consideration of any detriments, such as traffic accidents, expected to potentially result from decontamination and waste disposal;
- (b) The licensee has made provisions for legally enforceable institutional controls that provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year;

- (c) The licensee has provided sufficient financial assurance to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site. Acceptable financial assurance mechanisms are specified in paragraph ~~4200-02-10-12~~ (4) of Rule 0400-20-10-12; and
- (d) Residual radioactivity at the site has been reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is ALARA and would not exceed either:
1. 100 mrem (1 mSv) per year; or
 2. 500 mrem (5 mSv) per year provided the licensee:
 - (i) Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/y (1 mSv/y) value of part 1 ~~above of this subparagraph~~:
 - (I) Are not technically achievable,
 - (II) Would be prohibitively expensive or
 - (III) Would result in net public or environmental harm;
 - (ii) Makes provisions for durable institutional controls;
 - (iii) Provides sufficient financial assurance to enable a responsible government entity or independent third party, including a governmental custodian of a site, both to carry out periodic rechecks of the site and to assume and carry out responsibilities for any necessary control and maintenance of those controls. Periodic rechecks shall be carried out no less frequently than every ~~five~~ 5 years to assure that the institutional controls remain in place as necessary to meet the criteria of subparagraph ~~4200-02-10-36(3)~~ (b) of this paragraph. Acceptable financial assurance mechanisms are those in subparagraph ~~4200-02-10-12~~ (4)(d) of Rule 0400-20-10-12.
- (4) Alternate criteria for license termination.
- (a) The Division may terminate a license using alternate criteria greater than the dose criterion of paragraph ~~4200-02-10-36~~ (2) of this rule and subparagraph ~~4200-02-10-36~~ (3)(b) of this rule, if the licensee:
1. Provides assurance that public health and safety would continue to be protected, and that it is unlikely that the dose from all man-made sources combined, other than medical, would be more than the 1 mSv/y (100 mrem/y) limit of Rules ~~4200-02-05-60~~ 0400-20-05-60 and ~~4200-02-05-61~~ 0400-20-05-61, by submitting an analysis of possible sources of exposure;
 2. Has employed to the extent practicable restrictions on site use according to the provisions of paragraph ~~4200-02-10-36~~ (3) of this rule in minimizing exposures at the site; and
 - (i) Reduces doses to ALARA levels, taking into consideration any detriments such as traffic accidents expected to potentially result from decontamination and waste disposal.

(ii) Reserved.

(b) The use of alternate criteria to terminate a license requires the approval of the Division. The Division will consider staff recommendations to address any comments provided by the Environmental Protection Agency and any public comments submitted under paragraph (5) ~~below of this rule.~~

(5) Public notification and public participation.

Whenever the Division deems such notice to be in the public interest, the Division may:

(a) Notify and solicit comments from:

1. Local governments and other State government agencies in the vicinity of the site that could be affected by the decommissioning; and
2. The Environmental Protection Agency for cases where the licensee proposes to release a site under paragraph ~~1200-02-10-36~~ (4) of this rule.

(b) Publish a notice ~~in~~ on the Tennessee Administrative Register web site, and in another appropriate forum that is readily accessible to individuals near the site, and solicit comments from affected parties. Another appropriate forum may include local newspapers and letters to State or local organizations.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-37~~ 0400-20-10-37 Reserved.

(Note: The contents of Rule ~~1200-02-10-37~~ 0400-20-10-37 Schedule 10-6: Determination of A₁ and A₂ ~~are being have moved to the Appendix to this Chapter~~ ~~1200-02-10-38~~ Rule 0400-20-10-38.)

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

~~1200-02-10-38~~ 0400-20-10-38 Appendix—Schedules.

SCHEDULE RHS 8-3: EXEMPT QUANTITIES

Radioactive Material	Micro-curies
Antimony-122 (Sb 122)	100
Antimony-124 (Sb 124)	10
Antimony-125 (Sb 125)	10
Arsenic-73 (As 73)	100
Arsenic-74 (As 74)	10
Arsenic-76 (As 76)	10
Arsenic-77 (As 77)	100
Barium-131 (Ba 131)	10
Barium-133 (Ba 133)	10
Barium-140 (Ba 140)	10
Bismuth-210 (Bi 210)	1
Bromine-82 (Br 82)	10
Cadmium-109 (Cd 109)	10
Cadmium-115m (Cd 115m)	10
Cadmium-115 (Cd 115)	100
Calcium-45 (Ca 45)	10

Radioactive Material	Micro-curies
Calcium-47 (Ca 47)	10
Carbon-14 (C 14)	100
Cerium-141 (Ce 141)	100
Cerium-143 (Ce 143)	100
Cerium-144 (Ce 144)	1
Cesium-129 (Cs 129)	100
Cesium-131 (Cs 131)	1,000
Cesium-134m (Cs 134m)	100
Cesium-134 (Cs 134)	1
Cesium-135 (Cs 135)	10
Cesium-136 (Cs 136)	10
Cesium-137 (Cs 137)	10
Chlorine-36 (Cl 36)	10
Chlorine-38 (Cl 38)	10
Chromium-51 (Cr 51)	1,000
Cobalt-57 (Co 57)	100

Radioactive Material	Micro-curies
Cobalt-58m (Co 58m)	10
Cobalt-58 (Co 58)	10
Cobalt-60 (Co 60)	1
Copper-64 (Cu 64)	100
Dysprosium-165 (Dy 165)	10
Dysprosium-166 (Dy 166)	100
Erbium-169 (Er 169)	100
Erbium-171 (Er 171)	100
Europium-152 (Eu 152)9.2 h	100
Europium-152 (Eu 152)13 yr	1
Europium-154 (Eu 154)	1
Europium-155 (Eu 155)	10
Fluorine-18 (F 18)	1,000
Gadolinium-153 (Gd 153)	10
Gadolinium-159 (Gd 159)	100
Gallium-67 (Ga 67)	100
Gallium-72 (Ga 72)	10
Germanium-68 (Ge 68)	10
Germanium-71 (Ge 71)	100
Gold-195 (Au 195)	10
Gold-198 (Au 198)	100
Gold-199 (Au 199)	100
Hafnium-181 (Hf 181)	10
Holmium-166 (Ho 166)	100
Hydrogen-3 (H 3)	1,000
Indium-111 (In 111)	100
Indium-113m (In 113m)	100
Indium-114m (In 114m)	10
Indium-115m (In 115m)	100
Indium-115 (In 115)	10
Iodine-123 (I 123)	100
Iodine-125 (I 125)	1
Iodine-126 (I 126)	1
Iodine-129 (I 129)	0.1
Iodine-131 (I 131)	1
Iodine-132 (I 132)	10
Iodine-133 (I 133)	1
Iodine-134 (I 134)	10
Iodine-135 (I 135)	10
Iridium-192 (Ir 192)	10
Iridium-194 (Ir 194)	100
Iron-52 (Fe 52)	10
Iron-55 (Fe 55)	100
Iron-59 (Fe 59)	10
Krypton-85 (Kr 85)	100
Krypton-87 (Kr 87)	10
Lanthanum-140 (La 140)	10
Lutetium-177 (Lu 177)	100
Manganese-52 (Mn 52)	10
Manganese-54 (Mn 54)	10
Manganese-56 (Mn 56)	10
Mercury-197m (Hg 197m)	100

Radioactive Material	Micro-curies
Mercury-197 (Hg 197)	100
Mercury-203 (Hg 203)	10
Molybdenum-99 (Mo 99)	100
Neodymium-147(Nd 147)	100
Neodymium-149 (Nd 149)	100
Nickel-59 (Ni 59)	100
Nickel-63 (Ni 63)	10
Nickel-65 (Ni 65)	100
Niobium-93m (Nb 93m)	10
Niobium-95 (Nb 95)	10
Niobium-97 (Nb 97)	10
Osmium-185 (Os 185)	10
Osmium-191m (Os 191m)	100
Osmium-191 (Os 191)	100
Osmium-193 (Os 193)	100
Palladium-103 (Pd 103)	100
Palladium-109 (Pd 109)	100
Phosphorus-32 (P 32)	10
Platinum-191 (Pt 191)	100
Platinum-193m (Pt 193m)	100
Platinum-193 (Pt 193)	100
Platinum-197m (Pt 197m)	100
Platinum-197 (Pt 197)	100
Polonium-210 (Po 210)	0.1
Potassium-42 (K 42)	10
Potassium-43 (K 43)	10
Praseodymium-142 (Pr 142)	100
Praseodymium-143 (Pr 143)	100
Promethium-147 (Pm 147)	10
Promethium-149 (Pm 149)	10
Rhenium-186 (Re 186)	100
Rhenium-188 (Re 188)	100
Rhodium-103m (Rh 103m)	100
Rhodium-105 (Rh 105)	100
Rubidium-81 (Rb 81)	10
Rubidium-86 (Rb 86)	10
Rubidium-87 (Rb 87)	10
Ruthenium-97 (Ru 97)	100
Ruthenium-103 (Ru 103)	10
Ruthenium-105 (Ru 105)	10
Ruthenium-106 (Ru 106)	1
Samarium-151 (Sm 151)	10
Samarium-153 (Sm 153)	100
Scandium-46 (Sc 46)	10
Scandium-47 (Sc 47)	100
Scandium-48 (Sc 48)	10
Selenium-75 (Se 75)	10
Silicon-31 (Si 31)	100
Silver-105 (Ag 105)	10
Silver-110m (Ag 110m)	1
Silver-111 (Ag 111)	100
Sodium-22 (Na 22)	10

Radioactive Material	Micro-curies
Sodium-24 (Na 24)	10
Strontium-85 (Sr 85)	10
Strontium-89 (Sr 89)	1
Strontium-90 (Sr 90)	0.1
Strontium-91 (Sr 91)	10
Strontium-92 (Sr 92)	10
Sulfur-35 (S 35)	100
Tantalum-182 (Ta 182)	10
Technetium-96 (Tc 96)	10
Technetium-97m (Tc 97m)	100
Technetium-97 (Tc 97)	100
Technetium-99m (Tc 99m)	100
Technetium-99 (Tc 99)	10
Tellurium-125m (Te 125m)	10
Tellurium-127m (Te 127m)	10
Tellurium-127 (Te 127)	100
Tellurium-129m (Te 129m)	10
Tellurium-129 (Te 129)	100
Tellurium-131m (Te 131m)	10
Tellurium-132 (Te 132)	10
Terbium-160 (Tb 160)	10
Thallium-200 (Tl 200)	100
Thallium-201 (Tl 201)	100
Thallium-202 (Tl 202)	100
Thallium-204 (Tl 204)	10
Thulium-170 (Tm 170)	10
Thulium-171 (Tm 171)	10
Tin-113 (Sn 113)	10

Radioactive Material	Micro-curies
Tin-125 (Sn 125)	10
Tungsten-181 (W 181)	10
Tungsten-185 (W 185)	10
Tungsten-187 (W 187)	100
Vanadium-48 (V 48)	10
Xenon-131m (Xe 131m)	1,000
Xenon-133 (Xe 133)	100
Xenon-135 (Xe 135)	100
Ytterbium-175 (Yb 175)	100
Yttrium-87 (Y 87)	10
Yttrium-88 (Y 88)	10
Yttrium-90 (Y 90)	10
Yttrium-91 (Y 91)	10
Yttrium-92 (Y 92)	100
Yttrium-93 (Y 93)	100
Zinc-65 (Zn 65)	10
Zinc-69m (Zn 69m)	100
Zinc-69 (Zn 69)	1,000
Zirconium-93 (Zr 93)	10
Zirconium-95 (Zr 95)	10
Zirconium-97 (Zr 97)	10
Any radioactive material not listed above other than alpha-emitting radioactive material	0.1
Any alpha emitting radioactive material not listed above other than transuranic radioactive material	0.01

498

SCHEDULE RHS 8-4: EXEMPT CONCENTRATIONS

Element (atomic number)	Isotope	Column I Gas Concentration $\mu\text{Ci/ml}^a$	Column II and Solid Concentration $\mu\text{Ci/ml}^b$
Antimony (51)	Sb-122		3×10^{-4}
	Sb-124		2×10^{-4}
	Sb-125		1×10^{-3}
Argon (18)	Ar-37	1×10^{-3}	
	Ar-41	4×10^{-7}	
Arsenic (33)	As-73		5×10^{-3}
	As-74		5×10^{-4}
	As-76		2×10^{-4}
	As-77		8×10^{-4}
Barium (56)	Ba-131		2×10^{-3}
	Ba-140		3×10^{-4}
Beryllium (4)	Be-7		2×10^{-2}
Bismuth (83)	Bi-206		4×10^{-4}
Bromine (35)	Br-82	4×10^{-7}	3×10^{-3}
Cadmium (48)	Cd-109		2×10^{-3}
	Cd-115m		3×10^{-4}
	Cd-115		3×10^{-4}
Calcium (20)	Ca-45		9×10^{-6}
	Ca-47		5×10^{-4}
Carbon (6)	C-14	1×10^{-6}	8×10^{-3}
Cerium (58)	Ce-141		9×10^{-4}
	Ce-143		4×10^{-4}
	Ce-144		1×10^{-4}
Cesium (55)	Cs-131		2×10^{-2}
	Cs-134m		6×10^{-2}
	Cs-134		9×10^{-5}
Chlorine (17)	Cl-38	9×10^{-7}	4×10^{-3}
Chromium (24)	Cr-51		2×10^{-2}
Cobalt (27)	Co-57		5×10^{-3}
	Co-58		1×10^{-3}
	Co-60		5×10^{-4}
Copper (29)	Cu-64		3×10^{-3}
Dysprosium (66)	Dy-165		4×10^{-3}
	Dy-166		4×10^{-4}
Erbium (68)	Er-169		9×10^{-4}
	Er-171		1×10^{-3}
Europium (63)	Eu-152		6×10^{-4}
	(Tr = 9.2h)		
	Eu-155		2×10^{-3}
Fluorine(9)	F-18	2×10^{-6}	8×10^{-3}
Gadolinium (64)	Gd-153		2×10^{-3}
	Gd-159		8×10^{-4}
Gallium (31)	Ga-72		4×10^{-4}
Germanium (32)	Ge-71		2×10^{-2}
Gold (79)	Au-196		2×10^{-3}
	Au-198		5×10^{-4}
	Au-199		2×10^{-3}
Hafnium (72)	Hf-181		7×10^{-4}
Hydrogen (1)	H-3	5×10^{-6}	3×10^{-2}
Indium (49)	In-113m		1×10^{-2}
	In-114m		2×10^{-4}
Iodine (53)	I-126	3×10^{-9}	2×10^{-5}
	I-131	3×10^{-9}	2×10^{-5}

499

Element (atomic number)	Isotope	Column I Gas Concentration $\mu\text{Ci/ml}^a$	Column II and Solid Concentration $\mu\text{Ci/ml}^b$
	I-132	8×10^{-8}	6×10^{-4}
	I-133	1×10^{-8}	7×10^{-5}
	I-134	2×10^{-7}	1×10^{-3}
Iridium (77)	Ir-190		2×10^{-3}
	Ir-192		4×10^{-4}
	Ir-194		3×10^{-4}
Iron (26)	Fe-55		8×10^{-3}
	Fe-59		6×10^{-4}
Krypton (36)	Kr-85m	1×10^{-6}	
	Kr-85	3×10^{-6}	
Lanthanum (57)	La-140		2×10^{-4}
Lead (82)	Pb-203		4×10^{-3}
Lutetium (71)	Lu-177		1×10^{-3}
Manganese (25)	Mn-52		3×10^{-4}
	Mn-54		1×10^{-3}
	Mn-56		1×10^{-3}
Mercury (80)	Hg-197m		2×10^{-3}
	Hg-197		3×10^{-3}
	Hg-203		2×10^{-4}
Molybdenum (42)	Mo-99		2×10^{-3}
Neodymium (60)	Nd-147		6×10^{-4}
	Nd-149		3×10^{-3}
Nickel (28)	Ni-65		1×10^{-3}
Niobium (41)	Nb-95		1×10^{-3}
	Nb-97		9×10^{-3}
Osmium (76)	Os-185		7×10^{-4}
	Os-191m		3×10^{-2}
	Os-191		2×10^{-3}
	Os-193		6×10^{-4}
Palladium (46)	Pd-103		3×10^{-3}
	Pd-109		9×10^{-4}
Phosphorus (15)	P-32		2×10^{-4}
Platinum (78)	Pt-191		1×10^{-3}
	Pt-193m		1×10^{-2}
	Pt-197m		1×10^{-2}
	Pt-197		1×10^{-3}
Polonium (84)	Po-210		7×10^{-6}
Potassium (19)	K-42		3×10^{-3}
Praseodymium (59)	Pr-142		3×10^{-4}
	Pr-143		5×10^{-4}
Promethium (61)	Pm-147		2×10^{-3}
	Pm-149		4×10^{-4}
Radium (88)	Ra-226		1×10^{-7}
	Ra-228		3×10^{-7}
Rhenium (75)	Re-183		6×10^{-3}
	Re-186		9×10^{-4}
	Re-188		6×10^{-4}
Rhodium (45)	Rh-103m		1×10^{-1}
	Rh-105		1×10^{-3}
Rubidium (37)	Rb-86		7×10^{-4}
Ruthenium (44)	Ru-97		4×10^{-3}
	Ru-103		8×10^{-4}
	Ru-105		1×10^{-3}
	Ru-106		1×10^{-4}
Samarium (62)	Sm-153		8×10^{-4}
Scandium (21)	Sc-46		4×10^{-4}
	Sc-47		9×10^{-4}

Element (atomic number)	Isotope	Column I Gas Concentration $\mu\text{Ci/ml}^a$	Column II and Solid Concentration $\mu\text{Ci/ml}^b$
	Sc-48		3×10^{-4}
Selenium (34)	Se-75		3×10^{-3}
Silicon (14)	Si-31		9×10^{-3}
Silver (47)	Ag-105		1×10^{-3}
	Ag-110m		3×10^{-4}
	Ag-111		4×10^{-4}
Sodium (11)	Na-24		2×10^{-3}
Strontium (38)	Sr-85		1×10^{-4}
	Sr-89		1×10^{-4}
	Sr-91		7×10^{-4}
	Sr-92		7×10^{-4}
Sulfur (16)	S-35	9×10^{-8}	6×10^{-4}
Tantalum (73)	Ta-182		4×10^{-4}
Technetium (43)	Tc-96m		1×10^{-1}
	Tc-96		1×10^{-3}
Tellurium (52)	Te-125m		2×10^{-3}
	Te-127m		6×10^{-4}
	Te-127		3×10^{-3}
	Te-129m		3×10^{-4}
	Te-131m		6×10^{-4}
	Te-132		3×10^{-4}
Terbium (65)	Tb-160		4×10^{-4}
Thallium (81)	Tl-200		4×10^{-3}
	Tl-201		3×10^{-3}
	Tl-202		1×10^{-3}
	Tl-204		1×10^{-3}
Thulium (69)	Tm-170		5×10^{-4}
	Tm-171		5×10^{-3}
Tin (50)	Sn-113		9×10^{-4}
	Sn-125		2×10^{-4}
Tungsten (74)	W-181		4×10^{-3}
	W-187		7×10^{-4}
Vanadium (23)	V-48		3×10^{-4}
Xenon (54)	Xe-131m	4×10^{-6}	
	Xe-133	3×10^{-6}	
	Xe-135	1×10^{-6}	
Ytterbium (70)	Yb-175		1×10^{-3}
Yttrium (39)	Y-90		2×10^{-4}
	Y-91m		3×10^{-2}
	Y-91		3×10^{-4}
	Y-92		6×10^{-4}
	Y-93		3×10^{-4}
	Y-93		3×10^{-4}
Zinc (30)	Zn-65		1×10^{-3}
	Zn-69m		7×10^{-4}
	Zn-69		2×10^{-2}
Zirconium (40)	Zr-95		6×10^{-4}
	Zr-97		2×10^{-4}
Beta and/or gamma emitting radioactive material not listed above with half-life less than 3 years.		1×10^{-10}	1×10^{-6}

^a Values are given in Column I only for those materials normally used as gases.

^b $\mu\text{Ci/gm}$ for solids.

NOTE 1: Many radioisotopes disintegrate into isotopes that are also radioactive. In expressing the concentrations in Schedule RHS 8-4 the activity stated is that of the parent isotope and takes into account the daughters.

NOTE 2: For purposes of ~~4200-2-10-04~~ Rule 0400-20-10-04 where there is involved a combination of isotopes, the limit for the combination should be derived as follows: Determine for each isotope in the product the ratio between the concentration present in the product and the exempt concentration established in Schedule RHS 8-4 for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity).

EXAMPLE:

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} + \frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} \leq 1$$

SCHEDULE RHS 8-5: GENERAL LICENSING OF CERTAIN NAMED DEVICES

The following devices and equipment incorporating radioactive material, when manufactured, tested, and labeled by the manufacturer in accordance with the specification contained in a specific license or equivalent licensing document issued by the Division, the U.S. Nuclear Regulatory Commission or any Agreement State are placed under a general license pursuant to ~~4200-2-10-10~~ paragraph (1) of Rule 0400-20-10-10:

- (1) Static elimination device. Devices designed for use as static eliminators that contain, as a sealed source or sources, radioactive material consisting of a total of not more than 500 microcuries of polonium 210 per device.
- (2) Ion generating tube. Devices designed for ionization of air that contain, as a sealed source or sources, radioactive material consisting of a total of not more than 50 millicuries of hydrogen 3 (tritium) per device.

SCHEDULE 10-6: DETERMINATION OF A₁ AND A₂.

- (1) Values of A₁ and A₂ for individual radionuclides, which are the bases for many activity limits elsewhere in these regulations, are given in Table A-1. The curie (Ci) values specified are obtained by converting from the terabecquerel (TBq) figure. The curie values are expressed to three significant figures to assure that the difference in the TBq and Ci quantities is ~~1/10 of one percent~~ 0.1 % percent or less. Where values of A₁ or A₂ are unlimited, it is for radiation control purposes only. For nuclear criticality safety, some materials are subject to controls placed on fissile material.
- (2)
 - (a) For individual radionuclides whose identities are known but that are not listed in Table A-1, the A₁ and A₂ values contained in Table A-3 may be used. Otherwise, the licensee shall obtain prior Division approval of the A₁ and A₂ values for radionuclides not listed in Table A-1, before shipping the material.
 - (b) For individual radionuclides whose identities are known, but which are not listed in Table A-2, the exempt material activity concentration and exempt consignment activity values contained in Table A-3 may be used. Otherwise, the licensee shall obtain prior Division approval of the exempt material activity concentration and exempt consignment activity values for radionuclides not listed in Table A-2, before shipping the material.
 - (c) The licensee shall submit requests for prior approval, described under subparagraphs (2)(a) and (2)(b) of this Rule schedule, to the Division, in accordance with ~~4200-02-04-07~~ Rule 0400-20-04-07.
- (3) In the calculations of A₁ and A₂ for a radionuclide not in Table A-1, a single radioactive decay chain, in which radionuclides are present in their naturally occurring proportions, and in which no daughter nuclide has a half-life either longer than ~~ten~~ 10 days or longer than that of the parent nuclide, shall be considered as a single radionuclide. The activity to be taken into account, and the A₁ or A₂ value to be applied, shall be those corresponding to the parent nuclide of that chain. In the case of radioactive decay chains in which any daughter nuclide has a half-life either longer than ~~ten~~ 10 days or greater than that of the parent nuclide, the parent and those daughter nuclides shall be considered as mixtures of different nuclides.

(4) 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:

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

where B(i) is the activity of radionuclide I, and A₁(i) is the A₁ value for radionuclide I.

(b) For normal form radioactive material, the maximum quantity transported in a Type A package:

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

where B(i) is the activity of radionuclide I, and A₂(i) is the A₂ value for radionuclide I.

(c) Alternatively, an A₁ value for mixtures of special form material may be determined as follows:

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

Where f(i) is the fraction of activity of nuclide I in the mixture and A₁(i) is the appropriate A₁ value for nuclide I.

(d) An A₂ value for mixtures of normal form material may be determined as follows:

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

Where f(i) is the fraction of activity of nuclide I in the mixture and A₂(i) is the appropriate A₂ value for nuclide I.

(e) The exempt activity concentration for mixtures of nuclides may be determined as follows:

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

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

(f) 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 is the activity limit for exempt consignments for radionuclide I.

- (5) 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. The lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph (4) of this schedule. 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.

Table A-1— A_1 and A_2 VALUES FOR RADIONUCLIDES

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1 (Ci) ^b	A_2 (TBq)	A_2 (Ci) ^b	Specific activity	
						(TBq/g)	(Ci/g)
Ac-225 (a)	Actinium (89)	8.0×10^{-1}	2.2×10^1	6.0×10^{-3}	1.6×10^{-1}	2.1×10^3	5.8×10^4
Ac-227 (a)		9.0×10^{-1}	2.4×10^1	9.0×10^{-5}	2.4×10^{-3}	2.7	7.2×10^1
Ac-228		6.0×10^{-1}	1.6×10^1	5.0×10^{-1}	1.4×10^1	8.4×10^4	2.2×10^5
Ag-105	Silver (47)	2.0	5.4×10^1	2.0	5.4×10^1	1.1×10^3	3.0×10^4
Ag-108m (a)		7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1	9.7×10^{-1}	2.6×10^1
Ag-110m (a)		4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1	1.8×10^2	4.7×10^3
Ag-111		2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1	5.8×10^3	1.6×10^5
Al-26	Aluminum (13)	1.0×10^{-1}	2.7	1.0×10^{-1}	2.7	7.0×10^{-4}	1.9×10^{-2}
Am-241	Americium (95)	1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}	1.3×10^{-1}	3.4
Am-242m (a)		1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}	3.6×10^{-1}	1.0×10^1
Am-243 (a)		5.0	1.4×10^2	1.0×10^{-3}	2.7×10^{-2}	7.4×10^{-3}	2.0×10^{-1}
Ar-37	Argon (18)	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3	3.7×10^3	9.9×10^4
Ar-39		4.0×10^1	1.1×10^3	2.0×10^1	5.4×10^2	1.3	3.4×10^1
Ar-41		3.0×10^{-1}	8.1	3.0×10^{-1}	8.1	1.5×10^6	4.2×10^7
As-72	Arsenic (33)	3.0×10^{-1}	8.1	3.0×10^{-1}	8.1	6.2×10^4	1.7×10^5
As-73		4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3	8.2×10^2	2.2×10^4
As-74		1.0	2.7×10^1	9.0×10^{-1}	2.4×10^1	3.7×10^3	9.9×10^4
As-76		3.0×10^{-1}	8.1	3.0×10^{-1}	8.1	5.8×10^4	1.6×10^6
As-77		2.0×10^1	5.4×10^2	7.0×10^{-1}	1.9×10^1	3.9×10^4	1.0×10^6
At-211 (a)	Astatine (85)	2.0×10^1	5.4×10^2	5.0×10^{-1}	1.4×10^1	7.6×10^4	2.1×10^6
Au-193	Gold (79)	7.0	1.9×10^2	2.0	5.4×10^1	3.4×10^4	9.2×10^5
Au-194		1.0	2.7×10^1	1.0	2.7×10^1	1.5×10^4	4.1×10^5
Au-195		1.0×10^1	2.7×10^2	6.0	1.6×10^2	1.4×10^2	3.7×10^3
Au-198		1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1	9.0×10^3	2.4×10^5
Au-199		1.0×10^1	2.7×10^2	6.0×10^{-1}	1.6×10^1	7.7×10^3	2.1×10^5
Ba-131 (a)	Barium (56)	2.0	5.4×10^1	2.0	5.4×10^1	3.1×10^3	8.4×10^4
Ba-133		3.0	8.1×10^1	3.0	8.1×10^1	9.4	2.6×10^2
Ba-133m		2.0×10^1	5.4×10^2	6.0×10^{-1}	1.6×10^1	2.2×10^4	6.1×10^5
Ba-140 (a)		5.0×10^{-1}	1.4×10^1	3.0×10^{-1}	8.1	2.7×10^3	7.3×10^4
Be-7	Beryllium (4)	2.0×10^1	5.4×10^2	2.0×10^1	5.4×10^2	1.3×10^4	3.5×10^5
Be-10		4.0×10^1	1.1×10^3	6.0×10^{-1}	1.6×10^1	8.3×10^{-4}	2.2×10^{-2}
Bi-205	Bismuth (83)	7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1	1.5×10^3	4.2×10^4
Bi-206		3.0×10^{-1}	8.1	3.0×10^{-1}	8.1	3.8×10^3	1.0×10^5
Bi-207		7.0×10^{-1}	1.9×10^1	7.0×10^{-1}	1.9×10^1	1.9	5.2×10^1
Bi-210		1.0	2.7×10^1	6.0×10^{-1}	1.6×10^1	4.6×10^3	1.2×10^5
Bi-210m (a)		6.0×10^{-1}	1.6×10^1	2.0×10^{-2}	5.4×10^{-1}	2.1×10^{-5}	5.7×10^{-4}
Bi-212 (a)		7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1	5.4×10^5	1.5×10^7

Bk-247	Berkelium (97)	8.0	2.2X10 ²	8.0X10 ⁻⁴	2.2X10 ⁻²	3.8X10 ⁻²	1.0
Bk-249 (a)		4.0X10 ¹	1.1X10 ³	3.0X10 ⁻¹	8.1	6.1X10 ¹	1.6X10 ³
Br-76	Bromine (35)	4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	9.4X10 ⁴	2.5X10 ⁵
Br-77		3.0	8.1X10 ¹	3.0	8.1X10 ¹	2.6X10 ⁴	7.1X10 ⁵
Br-82		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻³	1.1X10 ¹	4.0X10 ⁴	1.1X10 ⁶
C-11	Carbon (6)	1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.1X10 ⁷	8.4X10 ⁸
C-14		4.0X10 ¹	1.1X10 ³	3.0	8.1X10 ¹	1.6X10 ⁻¹	4.5
Ca-41	Calcium (20)	Unlimited	Unlimited	Unlimited	Unlimited	3.1X10 ⁻³	8.5X10 ⁻²
Ca-45		4.0X10 ¹	1.1X10 ³	1.0	2.7X10 ¹	6.6X10 ²	1.8X10 ⁴
Ca-47 (a)		3.0	8.1X10 ¹	3.0X10 ⁻¹	8.1	2.3X10 ⁴	6.1X10 ⁵
Cd-109	Cadmium (48)	3.0X10 ¹	8.1X10 ²	2.0	5.4X10 ¹	9.6X10 ¹	2.6X10 ³
Cd-113m		4.0X10 ¹	1.1X10 ³	5.0X10 ⁻¹	1.4X10 ¹	8.3	2.2X10 ²
Cd-115 (a)		3.0	8.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.9X10 ⁴	5.1X10 ⁵
Cd-115m		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	9.4X10 ²	2.5X10 ⁴
Ce-139	Cerium (58)	7.0	1.9X10 ²	2.0	5.4X10 ¹	2.5X10 ²	6.8X10 ³
Ce-141		2.0X10 ¹	5.4X10 ²	6.0X10 ⁻¹	1.6X10 ¹	1.1X10 ³	2.8X10 ⁴
Ce-143		9.0X10 ⁻¹	2.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.5X10 ⁴	6.6X10 ⁵
Ce-144 (a)		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	1.2X10 ²	3.2X10 ³
Cf-248	Californium (98)	4.0X10 ¹	1.1X10 ³	6.0X10 ⁻³	1.6X10 ⁻¹	5.8X10 ¹	1.6X10 ³
Cf-249		3.0	8.1X10 ¹	8.0X10 ⁻⁴	2.2X10 ⁻²	1.5X10 ⁻¹	4.1
Cf-250		2.0X10 ¹	5.4X10 ²	2.0X10 ⁻³	5.4X10 ⁻²	4.0	1.1X10 ²
Cf-251		7.0	1.9X10 ²	7.0X10 ⁻⁴	1.9X10 ⁻²	5.9X10 ⁻²	1.6
Cf-252 (h)		5.0X10 ⁻²	1.4	3.0X10 ⁻³	8.1X10 ⁻²	2.0X10 ¹	5.4X10 ²
Cf-253 (a)		4.0X10 ¹	1.1X10 ³	4.0X10 ⁻²	1.1	1.1X10 ³	2.9X10 ⁴
Cf-254		1.0X10 ⁻³	2.7X10 ⁻²	1.0X10 ⁻³	2.7X10 ⁻²	3.1X10 ²	8.5X10 ³
Cl-36	Chlorine (17)	1.0X10 ¹	2.7X10 ²	6.0X10 ⁻¹	1.6X10 ¹	1.2X10 ⁻³	3.3X10 ⁻²
Cl-38		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	4.9X10 ⁵	1.3X10 ⁸
Cm-240	Curium (96)	4.0X10 ¹	1.1X10 ³	2.0X10 ⁻²	5.4X10 ⁻¹	7.5X10 ²	2.0X10 ⁴
Cm-241		2.0	5.4X10 ¹	1.0	2.7X10 ¹	6.1X10 ²	1.7X10 ⁴
Cm-242		4.0X10 ¹	1.1X10 ³	1.0X10 ⁻²	2.7X10 ⁻¹	1.2X10 ²	3.3X10 ³
Cm-243		9.0	2.4X10 ²	1.0X10 ⁻³	2.7X10 ⁻²	1.9X10 ⁻³	5.2X10 ¹
Cm-244		2.0X10 ¹	5.4X10 ²	2.0X10 ⁻³	5.4X10 ⁻²	3.0	8.1X10 ¹
Cm-245		9.0	2.4X10 ²	9.0X10 ⁻⁴	2.4X10 ⁻²	6.4X10 ⁻³	1.7X10 ⁻¹
Cm-246		9.0	2.4X10 ²	9.0X10 ⁻⁴	2.4X10 ⁻²	1.1X10 ⁻²	3.1X10 ⁻¹
Cm-247 (a)		3.0	8.1X10 ¹	1.0X10 ⁻³	2.7X10 ⁻²	3.4X10 ⁻⁶	9.3X10 ⁻⁵
Cm-248		2.0X10 ⁻²	5.4X10 ⁻¹	3.0X10 ⁻⁴	8.1X10 ⁻³	1.6X10 ⁻⁴	4.2X10 ⁻³
Co-55	Cobalt (27)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	1.1X10 ⁵	3.1X10 ⁶
Co-56		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.1X10 ³	3.0X10 ⁴
Co-57		1.0X10 ¹	2.7X10 ²	1.0X10 ¹	2.7X10 ²	3.1X10 ²	8.4X10 ³
Co-58		1.0	2.7X10 ¹	1.0	2.7X10 ¹	1.2X10 ³	3.2X10 ⁴
Co-58m		4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	2.2X10 ⁵	5.9X10 ⁶
Co-60		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	4.2X10 ¹	1.1X10 ³
Cr-51	Chromium (24)	3.0X10 ¹	8.1X10 ²	3.0X10 ¹	8.1X10 ²	3.4X10 ³	9.2X10 ⁴
Cs-129	Cesium (55)	4.0	1.1X10 ²	4.0	1.1X10 ²	2.8X10 ⁴	7.6X10 ⁵
Cs-131		3.0X10 ¹	8.1X10 ²	3.0X10 ¹	8.1X10 ²	3.8X10 ³	1.0X10 ⁵
Cs-132		1.0	2.7X10 ¹	1.0	2.7X10 ¹	5.7X10 ³	1.5X10 ⁵

Cs-134		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	4.8X10 ¹	1.3X10 ³
Cs-134m		4.0X10 ¹	1.1X10 ³	6.0X10 ⁻¹	1.6X10 ¹	3.0X10 ⁵	8.0X10 ⁶
Cs-135		4.0X10 ¹	1.1X10 ³	1.0	2.7X10 ¹	4.3X10 ⁵	1.2X10 ³
Cs-136		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	2.7X10 ³	7.3X10 ⁴
Cs-137 (a)		2.0	5.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.2	8.7X10 ¹
Cu-64	Copper (29)	6.0	1.6X10 ²	1.0	2.7X10 ¹	1.4X10 ⁵	3.9X10 ⁶
Cu-67		1.0X10 ¹	2.7X10 ²	7.0X10 ⁻¹	1.9X10 ¹	2.8X10 ⁴	7.6X10 ⁵
Dy-159	Dysprosium (66)	2.0X10 ¹	5.4X10 ²	2.0X10 ¹	5.4X10 ²	2.1X10 ²	5.7X10 ³
Dy-165		9.0X10 ⁻¹	2.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.0X10 ⁵	8.2X10 ⁶
Dy-166 (a)		9.0X10 ⁻¹	2.4X10 ¹	3.0X10 ⁻¹	8.1	8.6X10 ³	2.3X10 ⁵
Er-169	Erbium (68)	4.0X10 ¹	1.1X10 ³	1.0	2.7X10 ¹	3.1X10 ³	8.3X10 ⁴
Er-171		8.0X10 ⁻¹	2.2X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	9.0X10 ⁴	2.4X10 ⁶
Eu-147	Europium (63)	2.0	5.4X10 ¹	2.0	5.4X10 ¹	1.4X10 ³	3.7X10 ⁴
Eu-148		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	6.0X10 ²	1.6X10 ⁴
Eu-149		2.0X10 ¹	5.4X10 ²	2.0X10 ¹	5.4X10 ²	3.5X10 ²	9.4X10 ³
Eu-150 (short lived)		2.0	5.4X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	6.1X10 ⁴	1.6X10 ⁶
Eu-150 (long lived)		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	6.1X10 ⁴	1.6X10 ⁶
Eu-152		1.0	2.7X10 ¹	1.0	2.7X10 ¹	6.5	1.8X10 ²
Eu-152m		8.0X10 ⁻¹	2.2X10 ¹	8.0X10 ⁻¹	2.2X10 ¹	8.2X10 ⁴	2.2X10 ⁶
Eu-154		9.0X10 ⁻¹	2.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	9.8	2.6X10 ²
Eu-155		2.0X10 ¹	5.4X10 ²	3.0	8.1X10 ¹	1.8X10 ¹	4.9X10 ²
Eu-156		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	2.0X10 ³	5.5X10 ⁴
F-18	Fluorine (9)	1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.5X10 ⁶	9.5X10 ⁷
Fe-52 (a)	Iron (26)	3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	2.7X10 ⁵	7.3X10 ⁶
Fe-55		4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	8.8X10 ¹	2.4X10 ³
Fe-59		9.0X10 ⁻¹	2.4X10 ¹	9.0X10 ⁻¹	2.4X10 ¹	1.8X10 ³	5.0X10 ⁴
Fe-60 (a)		4.0X10 ¹	1.1X10 ³	2.0X10 ⁻¹	5.4	7.4X10 ⁴	2.0X10 ⁻²
Ga-67	Gallium (31)	7.0	1.9X10 ²	3.0	8.1X10 ¹	2.2X10 ⁴	6.0X10 ⁵
Ga-68		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	1.5X10 ⁶	4.1X10 ⁷
Ga-72		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.1X10 ⁵	3.1X10 ⁶
Gd-146 (a)	Gadolinium (64)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	6.9X10 ²	1.9X10 ⁴
Gd-148		2.0X10 ¹	5.4X10 ²	2.0X10 ⁻³	5.4X10 ⁻²	1.2	3.2X10 ¹
Gd-153		1.0X10 ¹	2.7X10 ²	9.0	2.4X10 ²	1.3X10 ²	3.5X10 ³
Gd-159		3.0	8.1X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.9X10 ⁴	1.1X10 ⁶
Ge-68 (a)	Germanium (32)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	2.6X10 ²	7.1X10 ³
Ge-71		4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	5.8X10 ³	1.6X10 ⁵
Ge-77		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.3X10 ⁵	3.6X10 ⁶
Hf-172 (a)	Hafnium (72)	6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	4.1X10 ¹	1.1X10 ³
Hf-175		3.0	8.1X10 ¹	3.0	8.1X10 ¹	3.9X10 ²	1.1X10 ⁴
Hf-181		2.0	5.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	6.3X10 ²	1.7X10 ⁴
Hf-182		Unlimited	Unlimited	Unlimited	Unlimited	8.1X10 ⁻⁶	2.2X10 ⁻⁴
Hg-194 (a)	Mercury (80)	1.0	2.7X10 ¹	1.0	2.7X10 ¹	1.3X10 ⁻¹	3.5
Hg-195m (a)		3.0	8.1X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	1.5X10 ⁴	4.0X10 ⁵
Hg-197		2.0X10 ¹	5.4X10 ²	1.0X10 ¹	2.7X10 ²	9.2X10 ³	2.5X10 ⁵
Hg-197m		1.0X10 ¹	2.7X10 ²	4.0X10 ⁻¹	1.1X10 ¹	2.5X10 ⁴	6.7X10 ⁵

Hg-203		5.0	1.4X10 ²	1.0	2.7X10 ¹	5.1X10 ²	1.4X10 ⁴
Ho-166	Holmium (67)	4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	2.6X10 ⁴	7.0X10 ⁵
Ho-166m		6.0X10 ⁻¹	1.6X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	6.6X10 ²	1.8
I-123	Iodine (53)	6.0	1.6X10 ²	3.0	8.1X10 ¹	7.1X10 ⁴	1.9X10 ⁵
I-124		1.0	2.7X10 ¹	1.0	2.7X10 ¹	9.3X10 ³	2.5X10 ⁵
I-125		2.0X10 ¹	5.4X10 ²	3.0	8.1X10 ¹	6.4X10 ²	1.7X10 ⁴
I-126		2.0	5.4X10 ¹	1.0	2.7X10 ¹	2.9X10 ³	8.0X10 ⁴
I-129		Unlimited	Unlimited	Unlimited	Unlimited	6.5X10 ⁻⁶	1.8X10 ⁻⁴
I-131		3.0	8.1X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	4.6X10 ³	1.2X10 ⁵
I-132		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	3.8X10 ⁵	1.0X10 ⁷
I-133		7.0X10 ⁻¹	1.9X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	4.2X10 ⁴	1.1X10 ⁵
I-134		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	9.9X10 ⁵	2.7X10 ⁷
I-135 (a)		6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.3X10 ⁵	3.5X10 ⁵
In-111	Indium (49)	3.0	8.1X10 ¹	3.0	8.1X10 ¹	1.5X10 ⁴	4.2X10 ⁵
In-113m		4.0	1.1X10 ²	2.0	5.4X10 ¹	6.2X10 ⁵	1.7X10 ⁷
In-114m (a)		1.0X10 ¹	2.7X10 ²	5.0X10 ⁻¹	1.4X10 ¹	8.6X10 ²	2.3X10 ⁴
In-115m		7.0	1.9X10 ²	1.0	2.7X10 ¹	2.2X10 ⁵	6.1X10 ⁵
Ir-189 (a)	Iridium (77)	1.0X10 ¹	2.7X10 ²	1.0X10 ¹	2.7X10 ²	1.9X10 ³	5.2X10 ⁴
Ir-190		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	2.3X10 ³	6.2X10 ⁴
Ir-192 (c)		1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.4X10 ²	9.2X10 ³
Ir-194		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	3.1X10 ⁴	8.4X10 ⁵
K-40	Potassium (19)	9.0X10 ⁻¹	2.4X10 ¹	9.0X10 ⁻¹	2.4X10 ¹	2.4X10 ⁻⁷	6.4X10 ⁻⁶
K-42		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	2.2X10 ⁵	6.0X10 ⁵
K-43		7.0X10 ⁻¹	1.9X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.2X10 ⁵	3.3X10 ⁵
Kr-81	Krypton (36)	4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	7.8X10 ⁻⁴	2.1X10 ⁻²
Kr-85		1.0X10 ¹	2.7X10 ²	1.0X10 ¹	2.7X10 ²	1.5X10 ¹	3.9X10 ²
Kr-85m		8.0	2.2X10 ²	3.0	8.1X10 ¹	3.0X10 ⁵	8.2X10 ⁵
Kr-87		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	1.0X10 ⁵	2.8X10 ⁷
La-137	Lanthanum (57)	3.0X10 ¹	8.1X10 ²	6.0	1.6X10 ²	1.6X10 ⁻³	4.4X10 ⁻²
La-140		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	2.1X10 ⁴	5.6X10 ⁵
Lu-172	Lutetium (71)	6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	4.2X10 ³	1.1X10 ⁵
Lu-173		8.0	2.2X10 ²	8.0	2.2X10 ²	5.6X10 ¹	1.5X10 ³
Lu-174		9.0	2.4X10 ²	9.0	2.4X10 ²	2.3X10 ¹	6.2X10 ²
Lu-174m		2.0X10 ¹	5.4X10 ²	1.0X10 ¹	2.7X10 ²	2.0X10 ²	5.3X10 ³
Lu-177		3.0X10 ¹	8.1X10 ²	7.0X10 ⁻¹	1.9X10 ¹	4.1X10 ³	1.1X10 ⁵
Mg-28 (a)	Magnesium (12)	3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	2.0X10 ⁵	5.4X10 ⁵
Mn-52	Manganese (25)	3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.6X10 ⁴	4.4X10 ⁵
Mn-53		Unlimited	Unlimited	Unlimited	Unlimited	6.8X10 ⁻⁵	1.8X10 ⁻³
Mn-54		1.0	2.7X10 ¹	1.0	2.7X10 ¹	2.9X10 ²	7.7X10 ³
Mn-56		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	8.0X10 ⁵	2.2X10 ⁷
Mo-93	Molybdenum (42)	4.0X10 ¹	1.1X10 ³	2.0X10 ¹	5.4X10 ²	4.1X10 ⁻²	1.1
Mo-99 (a) (i)		1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.8X10 ⁴	4.8X10 ⁵
N-13	Nitrogen (7)	9.0X10 ⁻¹	2.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	5.4X10 ⁷	1.5X10 ⁹
Na-22	Sodium (11)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	2.3X10 ²	6.3X10 ³
Na-24		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	3.2X10 ⁵	8.7X10 ⁵
Nb-93m	Niobium (41)	4.0X10 ¹	1.1X10 ³	3.0X10 ¹	8.1X10 ²	8.8	2.4X10 ²

Nb-94		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	6.9X10 ⁻³	1.9X10 ⁻¹
Nb-95		1.0	2.7X10 ¹	1.0	2.7X10 ¹	1.5X10 ³	3.9X10 ⁴
Nb-97		9.0X10 ⁻¹	2.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	9.9X10 ⁵	2.7X10 ⁷
Nd-147	Neodymium (60)	6.0	1.6X10 ²	6.0X10 ⁻¹	1.6X10 ¹	3.0X10 ³	8.1X10 ⁴
Nd-149		6.0X10 ⁻¹	1.6X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	4.5X10 ⁵	1.2X10 ⁷
Ni-59	Nickel (28)	Unlimited	Unlimited	Unlimited	Unlimited	3.0X10 ⁻³	8.0X10 ⁻²
Ni-63		4.0X10 ¹	1.1X10 ³	3.0X10 ¹	8.1X10 ²	2.1	5.7X10 ¹
Ni-65		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	7.1X10 ⁵	1.9X10 ⁷
Np-235	Neptunium (93)	4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	5.2X10 ¹	1.4X10 ³
Np-236 (short-lived)		2.0X10 ¹	5.4X10 ²	2.0	5.4X10 ¹	4.7X10 ⁻⁴	1.3X10 ⁻²
Np-236 (long-lived)		9.0X10 ⁰	2.4X10 ²	2.0X10 ⁻²	5.4X10 ⁻¹	4.7X10 ⁻⁴	1.3X10 ⁻²
Np-237		2.0X10 ¹	5.4X10 ²	2.0X10 ⁻³	5.4X10 ⁻²	2.6X10 ⁻⁵	7.1X10 ⁻⁴
Np-239		7.0	1.9X10 ²	4.0X10 ⁻¹	1.1X10 ¹	8.6X10 ³	2.3X10 ⁵
Os-185	Osmium (76)	1.0	2.7X10 ¹	1.0	2.7X10 ¹	2.8X10 ²	7.5X10 ³
Os-191		1.0X10 ¹	2.7X10 ²	2.0	5.4X10 ¹	1.6X10 ³	4.4X10 ⁴
Os-191m		4.0X10 ¹	1.1X10 ³	3.0X10 ¹	8.1X10 ²	4.6X10 ⁴	1.3X10 ⁶
Os-193		2.0	5.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.0X10 ⁴	5.3X10 ⁵
Os-194 (a)		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.1X10 ¹	3.1X10 ²
P-32	Phosphorus (15)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	1.1X10 ⁴	2.9X10 ⁵
P-33		4.0X10 ¹	1.1X10 ³	1.0	2.7X10 ¹	5.8X10 ³	1.6X10 ⁵
Pa-230 (a)	Protactinium (91)	2.0	5.4X10 ¹	7.0X10 ⁻²	1.9	1.2X10 ³	3.3X10 ⁴
Pa-231		4.0	1.1X10 ²	4.0X10 ⁻⁴	1.1X10 ⁻²	1.7X10 ⁻³	4.7X10 ⁻²
Pa-233		5.0	1.4X10 ²	7.0X10 ⁻¹	1.9X10 ¹	7.7X10 ²	2.1X10 ⁴
Pb-201	Lead (82)	1.0	2.7X10 ¹	1.0	2.7X10 ¹	6.2X10 ⁴	1.7X10 ⁶
Pb-202		4.0X10 ¹	1.1X10 ³	2.0X10 ¹	5.4X10 ²	1.2X10 ⁻⁴	3.4X10 ⁻³
Pb-203		4.0	1.1X10 ²	3.0	8.1X10 ¹	1.1X10 ⁴	3.0X10 ⁵
Pb-205		Unlimited	Unlimited	Unlimited	Unlimited	4.5X10 ⁻⁶	1.2X10 ⁻⁴
Pb-210 (a)		1.0	2.7X10 ¹	5.0X10 ⁻²	1.4	2.8	7.6X10 ¹
Pb-212 (a)		7.0X10 ⁻¹	1.9X10 ¹	2.0X10 ⁻¹	5.4	5.1X10 ⁴	1.4X10 ⁶
Pd-103 (a)	Palladium (46)	4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	2.8X10 ³	7.5X10 ⁴
Pd-107		Unlimited	Unlimited	Unlimited	Unlimited	1.9X10 ⁻⁵	5.1X10 ⁻⁴
Pd-109		2.0	5.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	7.9X10 ⁴	2.1X10 ⁶
Pm-143	Promethium (61)	3.0	8.1X10 ¹	3.0	8.1X10 ¹	1.3X10 ²	3.4X10 ³
Pm-144		7.0X10 ⁻¹	1.9X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	9.2X10 ¹	2.5X10 ³
Pm-145		3.0X10 ¹	8.1X10 ²	1.0X10 ¹	2.7X10 ²	5.2	1.4X10 ²
Pm-147		4.0X10 ¹	1.1X10 ³	2.0	5.4X10 ¹	3.4X10 ¹	9.3X10 ²
Pm-148m (a)		8.0X10 ⁻¹	2.2X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	7.9X10 ²	2.1X10 ⁴
Pm-149		2.0	5.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.5X10 ⁴	4.0X10 ⁵
Pm-151		2.0	5.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.7X10 ⁴	7.3X10 ⁵
Po-210	Polonium (84)	4.0X10 ¹	1.1X10 ³	2.0X10 ⁻²	5.4X10 ⁻¹	1.7X10 ²	4.5X10 ³
Pr-142	Praseodymium (59)	4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	4.3X10 ⁴	1.2X10 ⁶
Pr-143		3.0	8.1X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.5X10 ³	6.7X10 ⁴
Pt-188 (a)	Platinum (78)	1.0	2.7X10 ¹	8.0X10 ⁻¹	2.2X10 ¹	2.5X10 ³	6.8X10 ⁴
Pt-191		4.0	1.1X10 ²	3.0	8.1X10 ¹	8.7X10 ³	2.4X10 ⁵
Pt-193		4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	1.4	3.7X10 ¹

Pt-193m		4.0X10 ¹	1.1X10 ³	5.0X10 ⁻¹	1.4X10 ¹	5.8X10 ³	1.6X10 ⁵
Pt-195m		1.0X10 ¹	2.7X10 ²	5.0X10 ⁻¹	1.4X10 ¹	6.2X10 ³	1.7X10 ⁵
Pt-197		2.0X10 ¹	5.4X10 ²	6.0X10 ⁻¹	1.6X10 ¹	3.2X10 ⁴	8.7X10 ⁵
Pt-197m		1.0X10 ¹	2.7X10 ²	6.0X10 ⁻¹	1.6X10 ¹	3.7X10 ⁵	1.0X10 ⁷
Pu-236	Plutonium (94)	3.0X10 ¹	8.1X10 ²	3.0X10 ⁻³	8.1X10 ⁻²	2.0X10 ¹	5.3X10 ²
Pu-237		2.0X10 ¹	5.4X10 ²	2.0X10 ¹	5.4X10 ²	4.5X10 ²	1.2X10 ⁴
Pu-238		1.0X10 ¹	2.7X10 ²	1.0X10 ⁻³	2.7X10 ⁻²	6.3X10 ⁻¹	1.7X10 ¹
Pu-239		1.0X10 ¹	2.7X10 ²	1.0X10 ⁻³	2.7X10 ⁻²	2.3X10 ⁻³	6.2X10 ⁻²
Pu-240		1.0X10 ¹	2.7X10 ²	1.0X10 ⁻³	2.7X10 ⁻²	8.4X10 ⁻³	2.3X10 ⁻¹
Pu-241 (a)		4.0X10 ¹	1.1X10 ³	6.0X10 ⁻²	1.6	3.8	1.0X10 ²
Pu-242		1.0X10 ¹	2.7X10 ²	1.0X10 ⁻³	2.7X10 ⁻²	1.5X10 ⁻⁴	3.9X10 ⁻³
Pu-244 (a)		4.0X10 ⁻¹	1.1X10 ¹	1.0X10 ⁻³	2.7X10 ⁻²	6.7X10 ⁻⁷	1.8X10 ⁻⁵
Ra-223 (a)	Radium (88)	4.0X10 ⁻¹	1.1X10 ¹	7.0X10 ⁻³	1.9X10 ⁻¹	1.9X10 ³	5.1X10 ⁴
Ra-224 (a)		4.0X10 ⁻¹	1.1X10 ¹	2.0X10 ⁻²	5.4X10 ⁻¹	5.9X10 ³	1.6X10 ⁵
Ra-225 (a)		2.0X10 ⁻¹	5.4	4.0X10 ⁻³	1.1X10 ⁻¹	1.5X10 ³	3.9X10 ⁴
Ra-226 (a)		2.0X10 ⁻¹	5.4	3.0X10 ⁻³	8.1X10 ⁻²	3.7X10 ⁻²	1.0
Ra-228 (a)		6.0X10 ⁻¹	1.6X10 ¹	2.0X10 ⁻²	5.4X10 ⁻¹	1.0X10 ¹	2.7X10 ²
Rb-81	Rubidium (37)	2.0	5.4X10 ¹	8.0X10 ⁻¹	2.2X10 ¹	3.1X10 ⁵	8.4X10 ⁶
Rb-83 (a)		2.0	5.4X10 ¹	2.0	5.4X10 ¹	6.8X10 ²	1.8X10 ⁴
Rb-84		1.0	2.7X10 ¹	1.0	2.7X10 ¹	1.8X10 ³	4.7X10 ⁴
Rb-86		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	3.0X10 ³	8.1X10 ⁴
Rb-87		Unlimited	Unlimited	Unlimited	Unlimited	3.2X10 ⁻⁹	8.6X10 ⁻⁸
Rb(nat)		Unlimited	Unlimited	Unlimited	Unlimited	6.7X10 ⁶	1.8X10 ⁸
Re-184	Rhenium (75)	1.0	2.7X10 ¹	1.0	2.7X10 ¹	6.9X10 ²	1.9X10 ⁴
Re-184m		3.0	8.1X10 ¹	1.0	2.7X10 ¹	1.6X10 ²	4.3X10 ³
Re-186		2.0	5.4X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	6.9X10 ³	1.9X10 ⁵
Re-187		Unlimited	Unlimited	Unlimited	Unlimited	1.4X10 ⁻⁹	3.8X10 ⁻⁸
Re-188		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	3.6X10 ⁴	9.8X10 ⁵
Re-189 (a)		3.0	8.1X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.5X10 ⁴	6.8X10 ⁵
Re(nat)		Unlimited	Unlimited	Unlimited	Unlimited	0.0	2.4X10 ⁻⁸
Rh-99	Rhodium (45)	2.0	5.4X10 ¹	2.0	5.4X10 ¹	3.0X10 ³	8.2X10 ⁴
Rh-101		4.0	1.1X10 ²	3.0	8.1X10 ¹	4.1X10 ¹	1.1X10 ³
Rh-102		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	4.5X10 ¹	1.2X10 ³
Rh-102m		2.0	5.4X10 ¹	2.0	5.4X10 ¹	2.3X10 ²	6.2X10 ³
Rh-103m		4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	1.2X10 ⁶	3.3X10 ⁷
Rh-105		1.0X10 ¹	2.7X10 ²	8.0X10 ⁻¹	2.2X10 ¹	3.1X10 ⁴	8.4X10 ⁵
Rn-222 (a)	Radon (86)	3.0X10 ⁻¹	8.1	4.0X10 ⁻³	1.1X10 ⁻¹	5.7X10 ³	1.5X10 ⁵
Ru-97	Ruthenium (44)	5.0	1.4X10 ²	5.0	1.4X10 ²	1.7X10 ⁴	4.6X10 ⁵
Ru-103 (a)		2.0	5.4X10 ¹	2.0	5.4X10 ¹	1.2X10 ³	3.2X10 ⁴
Ru-105		1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	2.5X10 ⁵	6.7X10 ⁶
Ru-106 (a)		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	1.2X10 ²	3.3X10 ³
S-35	Sulphur (16)	4.0X10 ¹	1.1X10 ³	3.0	8.1X10 ¹	1.6X10 ³	4.3X10 ⁴
Sb-122	Antimony (51)	4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.5X10 ⁴	4.0X10 ⁵
Sb-124		6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	6.5X10 ²	1.7X10 ⁴
Sb-125		2.0	5.4X10 ¹	1.0	2.7X10 ¹	3.9X10 ¹	1.0X10 ³
Sb-126		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	3.1X10 ³	8.4X10 ⁴

Sc-44	Scandium (21)	5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	6.7X10 ⁵	1.8X10 ⁷
Sc-46		5.0X10 ⁻¹	1.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	1.3X10 ³	3.4X10 ⁴
Sc-47		1.0X10 ¹	2.7X10 ²	7.0X10 ⁻¹	1.9X10 ¹	3.1X10 ⁴	8.3X10 ⁵
Sc-48		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	5.5X10 ⁴	1.5X10 ⁶
Se-75	Selenium (34)	3.0	8.1X10 ¹	3.0	8.1X10 ¹	5.4X10 ²	1.5X10 ⁴
Se-79		4.0X10 ¹	1.1X10 ³	2.0	5.4X10 ¹	2.6X10 ³	7.0X10 ⁻²
Si-31	Silicon (14)	6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.4X10 ⁵	3.9X10 ⁷
Si-32		4.0X10 ¹	1.1X10 ³	5.0X10 ⁻¹	1.4X10 ¹	3.9	1.1X10 ²
Sm-145	Samarium (62)	1.0X10 ¹	2.7X10 ²	1.0X10 ¹	2.7X10 ²	9.8X10 ¹	2.6X10 ³
Sm-147		Unlimited	Unlimited	Unlimited	Unlimited	8.5X10 ⁻¹	2.3X10 ⁻⁸
Sm-151		4.0X10 ¹	1.1X10 ³	1.0X10 ¹	2.7X10 ²	9.7X10 ⁻¹	2.6X10 ¹
Sm-153		9.0	2.4X10 ²	6.0X10 ⁻¹	1.6X10 ¹	1.6X10 ⁴	4.4X10 ⁵
Sn-113 (a)	Tin (50)	4.0	1.1X10 ²	2.0	5.4X10 ¹	3.7X10 ²	1.0X10 ⁴
Sn-117m		7.0	1.9X10 ²	4.0X10 ⁻¹	1.1X10 ¹	3.0X10 ³	8.2X10 ⁴
Sn-119m		4.0X10 ¹	1.1X10 ³	3.0X10 ¹	8.1X10 ²	1.4X10 ²	3.7X10 ³
Sn-121m (a)		4.0X10 ¹	1.1X10 ³	9.0X10 ⁻¹	2.4X10 ¹	2.0	5.4X10 ¹
Sn-123		8.0X10 ⁻¹	2.2X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	3.0X10 ²	8.2X10 ³
Sn-125		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ³	1.1X10 ⁵
Sn-126 (a)		6.0X10 ⁻¹	1.6X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.0X10 ⁻³	2.8X10 ⁻²
Sr-82 (a)	Strontium (38)	2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	2.3X10 ³	6.2X10 ⁴
Sr-85		2.0	5.4X10 ¹	2.0	5.4X10 ¹	8.8X10 ²	2.4X10 ⁴
Sr-85m		5.0	1.4X10 ²	5.0	1.4X10 ²	1.2X10 ⁵	3.3X10 ⁷
Sr-87m		3.0	8.1X10 ¹	3.0	8.1X10 ¹	4.8X10 ⁵	1.3X10 ⁷
Sr-89		6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.1X10 ³	2.9X10 ⁴
Sr-90 (a)		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	5.1	1.4X10 ²
Sr-91 (a)		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.3X10 ⁵	3.6X10 ⁶
Sr-92 (a)		1.0	2.7X10 ¹	3.0X10 ⁻¹	8.1	4.7X10 ⁵	1.3X10 ⁷
T(H-3)	Tritium (1)	4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	3.6X10 ²	9.7X10 ³
Ta-178 (long-lived)	Tantalum (73)	1.0	2.7X10 ¹	8.0X10 ⁻¹	2.2X10 ¹	4.2X10 ⁵	1.1X10 ⁸
Ta-179		3.0X10 ¹	8.1X10 ²	3.0X10 ¹	8.1X10 ²	4.1X10 ¹	1.1X10 ³
Ta-182		9.0X10 ⁻¹	2.4X10 ¹	5.0X10 ⁻¹	1.4X10 ¹	2.3X10 ²	6.2X10 ³
Tb-157	Terbium (65)	4.0X10 ¹	1.1X10 ³	4.0X10 ¹	1.1X10 ³	5.6X10 ⁻¹	1.5X10 ¹
Tb-158		1.0	2.7X10 ¹	1.0	2.7X10 ¹	5.6X10 ⁻¹	1.5X10 ¹
Tb-160		1.0	2.7X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	4.2X10 ²	1.1X10 ⁴
Tc-95m (a)	Technetium (43)	2.0	5.4X10 ¹	2.0	5.4X10 ¹	8.3X10 ²	2.2X10 ⁴
Tc-96		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.2X10 ⁴	3.2X10 ⁵
Tc-96m (a)		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	1.4X10 ⁵	3.8X10 ⁷
Tc-97		Unlimited	Unlimited	Unlimited	Unlimited	5.2X10 ⁻⁵	1.4X10 ⁻³
Tc-97m		4.0X10 ¹	1.1X10 ³	1.0	2.7X10 ¹	5.6X10 ²	1.5X10 ⁴
Tc-98		8.0X10 ⁻¹	2.2X10 ¹	7.0X10 ⁻¹	1.9X10 ¹	3.2X10 ⁻⁵	8.7X10 ⁻⁴
Tc-99		4.0X10 ¹	1.1X10 ³	9.0X10 ⁻¹	2.4X10 ¹	6.3X10 ⁻⁴	1.7X10 ⁻²
Tc-99m		1.0X10 ¹	2.7X10 ²	4.0	1.1X10 ²	1.9X10 ⁵	5.3X10 ⁵
Te-121	Tellurium (52)	2.0	5.4X10 ¹	2.0	5.4X10 ¹	2.4X10 ³	6.4X10 ⁴
Te-121m		5.0	1.4X10 ²	3.0	8.1X10 ¹	2.6X10 ²	7.0X10 ³
Te-123m		8.0	2.2X10 ²	1.0	2.7X10 ¹	3.3X10 ²	8.9X10 ³
Te-125m		2.0X10 ¹	5.4X10 ²	9.0X10 ⁻¹	2.4X10 ¹	6.7X10 ²	1.8X10 ⁴

Te-127		2.0×10^1	5.4×10^2	7.0×10^{-1}	1.9×10^1	9.8×10^4	2.6×10^6
Te-127m (a)		2.0×10^1	5.4×10^2	5.0×10^{-1}	1.4×10^1	3.5×10^2	9.4×10^3
Te-129		7.0×10^{-1}	1.9×10^1	6.0×10^{-1}	1.6×10^1	7.7×10^5	2.1×10^7
Te-129m (a)		8.0×10^{-1}	2.2×10^1	4.0×10^{-1}	1.1×10^1	1.1×10^3	3.0×10^4
Te-131m (a)		7.0×10^{-1}	1.9×10^1	5.0×10^{-1}	1.4×10^1	3.0×10^4	8.0×10^5
Te-132 (a)		5.0×10^{-1}	1.4×10^1	4.0×10^{-1}	1.1×10^1	3.1×10^4	3.0×10^5
Th-227	Thorium (90)	1.0×10^1	2.7×10^2	5.0×10^{-3}	1.4×10^{-1}	1.1×10^3	3.1×10^4
Th-228 (a)		5.0×10^{-1}	1.4×10^1	1.0×10^{-3}	2.7×10^{-2}	3.0×10^1	8.2×10^2
Th-229		5.0	1.4×10^2	5.0×10^{-4}	1.4×10^{-2}	7.9×10^{-3}	2.1×10^{-1}
Th-230		1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}	7.6×10^{-4}	2.1×10^{-2}
Th-231		4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}	2.0×10^4	5.3×10^5
Th-232		Unlimited	Unlimited	Unlimited	Unlimited	4.0×10^{-9}	1.1×10^{-7}
Th-234 (a)		3.0×10^{-1}	8.1	3.0×10^{-1}	8.1	8.6×10^2	2.3×10^4
Th(nat)		Unlimited	Unlimited	Unlimited	Unlimited	8.1×10^{-9}	2.2×10^{-7}
Ti-44 (a)	Titanium (22)	5.0×10^{-1}	1.4×10^1	4.0×10^{-1}	1.1×10^1	6.4	1.7×10^2
Tl-200	Thallium (81)	9.0×10^{-1}	2.4×10^1	9.0×10^{-1}	2.4×10^1	2.2×10^4	6.0×10^5
Tl-201		1.0×10^1	2.7×10^2	4.0	1.1×10^2	7.9×10^3	2.1×10^5
Tl-202		2.0	5.4×10^1	2.0	5.4×10^1	2.0×10^3	5.3×10^4
Tl-204		1.0×10^1	2.7×10^2	7.0×10^{-1}	1.9×10^1	1.7×10^1	4.6×10^2
Tm-167	Thulium (69)	7.0	1.9×10^2	8.0×10^{-1}	2.2×10^1	3.1×10^3	8.5×10^4
Tm-170		3.0	8.1×10^1	6.0×10^{-1}	1.6×10^1	2.2×10^2	6.0×10^3
Tm-171		4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3
U-230 (fast lung absorption) (a)(d)	Uranium (92)	4.0×10^1	1.1×10^3	1.0×10^{-1}	2.7	1.0×10^3	2.7×10^4
U-230 (medium lung absorption) (a)(e)		4.0×10^1	1.1×10^3	4.0×10^{-3}	1.1×10^{-1}	1.0×10^3	2.7×10^4
U-230 (slow lung absorption) (a)(f)		3.0×10^1	8.1×10^2	3.0×10^{-3}	8.1×10^{-2}	1.0×10^3	2.7×10^4
U-232 (fast lung absorption) (d)		4.0×10^1	1.1×10^3	1.0×10^{-2}	2.7×10^{-1}	8.3×10^{-1}	2.2×10^1
U-232 (medium lung absorption) (e)		4.0×10^1	1.1×10^3	7.0×10^{-3}	1.9×10^{-1}	8.3×10^{-1}	2.2×10^1
U-232 (slow lung absorption) (f)		1.0×10^1	2.7×10^2	1.0×10^{-3}	2.7×10^{-2}	8.3×10^{-1}	2.2×10^1
U-233 (fast lung absorption) (d)		4.0×10^1	1.1×10^3	9.0×10^{-2}	2.4	3.6×10^{-4}	9.7×10^{-3}
U-233 (medium lung absorption) (e)		4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}	3.6×10^{-4}	9.7×10^{-3}

U-233 (slow lung absorption) (f)		4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}	3.6×10^{-4}	9.7×10^{-3}
U-234 (fast lung absorption) (d)		4.0×10^1	1.1×10^3	9.0×10^{-2}	2.4	2.3×10^{-4}	6.2×10^{-3}
U-234 (medium lung absorption) (e)		4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}	2.3×10^{-4}	6.2×10^{-3}
U-234 (slow lung absorption) (f)		4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}	2.3×10^{-4}	6.2×10^{-3}
U-235 (all lung absorption types) (a),(d),(e),(f)		Unlimited	Unlimited	Unlimited	Unlimited	8.0×10^{-8}	2.2×10^{-6}
U-236 (fast lung absorption) (d)		Unlimited	Unlimited	Unlimited	Unlimited	2.4×10^{-5}	6.5×10^{-5}
U-236 (medium lung absorption) (e)		4.0×10^1	1.1×10^3	2.0×10^{-2}	5.4×10^{-1}	2.4×10^{-6}	6.5×10^{-5}
U-236 (slow lung absorption) (f)		4.0×10^1	1.1×10^3	6.0×10^{-3}	1.6×10^{-1}	2.4×10^{-6}	6.5×10^{-5}
U-238 (all lung absorption types) (d),(e),(f)		Unlimited	Unlimited	Unlimited	Unlimited	1.2×10^{-8}	3.4×10^{-7}
U (nat)		Unlimited	Unlimited	Unlimited	Unlimited	2.6×10^{-8}	7.1×10^{-7}
U (enriched to 20% or less) (g)		Unlimited	Unlimited	Unlimited	Unlimited	See Table A-4	See Table A-4
U (dep)		Unlimited	Unlimited	Unlimited	Unlimited	See Table A-4	(See Table A-3)
V-48	Vanadium (23)	4.0×10^1	1.1×10^1	4.0×10^{-1}	1.1×10^1	6.3×10^3	1.7×10^5
V-49		4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3	3.0×10^2	8.1×10^3
W-178 (a)	Tungsten (74)	9.0	2.4×10^2	5.0	1.4×10^2	1.3×10^3	3.4×10^4
W-181		3.0×10^1	8.1×10^2	3.0×10^1	8.1×10^2	2.2×10^2	6.0×10^3
W-185		4.0×10^1	1.1×10^3	8.0×10^{-1}	2.2×10^1	3.5×10^2	9.4×10^3
W-187		2.0	5.4×10^1	6.0×10^{-1}	1.6×10^1	2.6×10^4	7.0×10^5
W-188 (a)		4.0×10^{-1}	1.1×10^1	3.0×10^{-1}	8.1	3.7×10^2	1.0×10^4
Xe-122 (a)	Xenon (54)	4.0×10^{-1}	1.1×10^1	4.0×10^{-1}	1.1×10^1	4.8×10^4	1.3×10^6
Xe-123		2.0	5.4×10^1	7.0×10^{-1}	1.9×10^1	4.4×10^5	1.2×10^7
Xe-127		4.0	1.1×10^2	2.0	5.4×10^1	1.0×10^3	2.8×10^4
Xe-131m		4.0×10^1	1.1×10^3	4.0×10^1	1.1×10^3	3.1×10^3	8.4×10^4
Xe-133		2.0×10^1	5.4×10^2	1.0×10^1	2.7×10^2	6.9×10^3	1.9×10^5
Xe-135		3.0	8.1×10^1	2.0	5.4×10^1	9.5×10^4	2.6×10^6
Y-87 (a)	Yttrium (39)	1.0	2.7×10^1	1.0	2.7×10^1	1.7×10^4	4.5×10^5

Y-88		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	5.2X10 ²	1.4X10 ⁴
Y-90		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	2.0X10 ⁴	5.4X10 ⁵
Y-91		6.0X10 ⁻¹	1.6X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	9.1X10 ²	2.5X10 ⁴
Y-91m		2.0	5.4X10 ¹	2.0	5.4X10 ¹	1.5X10 ⁶	4.2X10 ⁷
Y-92		2.0X10 ⁻¹	5.4	2.0X10 ⁻¹	5.4	3.6X10 ⁵	9.6X10 ⁶
Y-93		3.0X10 ⁻¹	8.1	3.0X10 ⁻¹	8.1	1.2X10 ⁵	3.3X10 ⁶
Yb-169	Ytterbium (70)	4.0	1.1X10 ²	1.0	2.7X10 ¹	8.9X10 ²	2.4X10 ⁴
Yb-175		3.0X10 ¹	8.1X10 ²	9.0X10 ⁻¹	2.4X10 ¹	6.6X10 ³	1.8X10 ⁵
Zn-65	Zinc (30)	2.0	5.4X10 ¹	2.0	5.4X10 ¹	3.0X10 ²	8.2X10 ³
Zn-69		3.0	8.1X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.8X10 ⁶	4.9X10 ⁷
Zn-69m (a)		3.0	8.1X10 ¹	6.0X10 ⁻¹	1.6X10 ¹	1.2X10 ⁵	3.3X10 ⁶
Zr-88	Zirconium (40)	3.0	8.1X10 ¹	3.0	8.1X10 ¹	6.6X10 ²	1.8X10 ⁴
Zr-93		Unlimited	Unlimited	Unlimited	Unlimited	9.3X10 ⁻⁵	2.5X10 ⁻³
Zr-95 (a)		2.0	5.4X10 ¹	8.0X10 ⁻¹	2.2X10 ¹	7.9X10 ²	2.1X10 ⁴
Zr-97 (a)		4.0X10 ⁻¹	1.1X10 ¹	4.0X10 ⁻¹	1.1X10 ¹	7.1X10 ⁴	1.9X10 ⁶

^a A₁ and/or A₂ values include contributions from daughter nuclides with half-lives less than 10 days.

^b The values of A₁ and A₂ in Curies (Ci) are approximate and for information only; the regulatory standard units are Terabecquerels (TBq), (see paragraph (1) of Schedule 10-6 of this appendix rule.).

^c The quantity 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 UF₆, UO₂F₂ and UO₂(NO₃)₂ in both normal and accident conditions of transport.

^e These values apply only to compounds of uranium that take the chemical form of UO₃, UF₄, UCl₄ 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) of this table.

^g These values apply to unirradiated uranium only.

^h A₁ = 0.1 TBq (2.7 Ci) and A₂ = 0.001 TBq (0.027 Ci) for Cf-252 for domestic use.

ⁱ A₂ = 0.74 TBq (20 Ci) for Mo-99 for domestic use.

Table A-2—EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES

Symbol of radionuclide	Element and atomic number	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)
Ac-225	Actinium (89)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Ac-227		1.0X10 ⁻¹	2.7X10 ⁻¹²	1.0X10 ³	2.7X10 ⁻⁸
Ac-228		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁵
Ag-105	Silver (47)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ag-108m (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Ag-110m		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Ag-111		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Al-26	Aluminum (13)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Am-241	Americium (95)	1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Am-242m (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Am-243 (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Ar-37	Argon (18)	1.0X10 ⁶	2.7X10 ⁻⁵	1.0X10 ⁸	2.7X10 ⁻³
Ar-39		1.0X10 ⁷	2.7X10 ⁻⁴	1.0X10 ⁴	2.7X10 ⁻⁷
Ar-41		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁹	2.7X10 ⁻²
As-72	Arsenic (33)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
As-73		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
As-74		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
As-76		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
As-77		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵

At-211	Astatine (85)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Au-193	Gold (79)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Au-194		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Au-195		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Au-198		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Au-199		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ba-131	Barium (56)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ba-133		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ba-133m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ba-140 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Be-7	Beryllium (4)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Be-10		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Bi-205	Bismuth (83)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Bi-206		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Bi-207		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Bi-210		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Bi-210m		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Bi-212 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Bk-247	Berkelium (97)	1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Bk-249		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Br-76	Bromine (35)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Br-77		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Br-82		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
C-11	Carbon (6)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
C-14		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Ca-41	Calcium (20)	1.0X10 ⁵	2.7X10 ⁻⁶	1.0X10 ⁷	2.7X10 ⁻⁴
Ca-45		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Ca-47		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Cd-109	Cadmium (48)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Cd-113m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Cd-115		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Cd-115m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Ce-139	Cerium (58)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ce-141		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Ce-143		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ce-144 (b)		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Cf-248	Californium (98)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cf-249		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Cf-250		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cf-251		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Cf-252		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cf-253		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Cf-254		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Cl-36	Chlorine (17)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Cl-38		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Cm-240	Curium (96)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶

Cm-241		1.0X10 ²	2.7X10 ⁹	1.0X10 ⁶	2.7X10 ⁵
Cm-242		1.0X10 ²	2.7X10 ⁹	1.0X10 ⁵	2.7X10 ⁶
Cm-243		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Cm-244		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cm-245		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Cm-246		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Cm-247		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Cm-248		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Co-55	Cobalt (27)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Co-56		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Co-57		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Co-58		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Co-58m		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Co-60		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁵
Cr-51	Chromium (24)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Cs-129	Cesium (55)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Cs-131		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Cs-132		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Cs-134		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cs-134m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
Cs-135		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Cs-136		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Cs-137 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Cu-64	Copper (29)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Cu-67		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Dy-159	Dysprosium (66)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Dy-165		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Dy-166		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Er-169	Erbium (68)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Er-171		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-147	Europium (63)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-148		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-149		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Eu-150 (short lived)		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-150 (long lived)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-152		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-152m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-154		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Eu-155		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Eu-156		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
F-18	Fluorine (9)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Fe-52	Iron (26)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Fe-55		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Fe-59		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Fe-60		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶

Ga-67	Gallium (31)	1.0X10 ²	2.7X10 ⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ga-68		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Ga-72		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Gd-146	Gadolinium (64)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Gd-148		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Gd-153		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Gd-159		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Ge-68	Germanium (32)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Ge-71		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁸	2.7X10 ⁻³
Ge-77		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Hf-172	Hafnium (72)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Hf-175		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Hf-181		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Hf-182		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Hg-194	Mercury (80)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Hg-195m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Hg-197		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Hg-197m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Hg-203		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Ho-166	Holmium (67)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
Ho-166m		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
I-123	Iodine (53)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
I-124		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
I-125		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁵
I-126		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
I-129		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
I-131		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
I-132		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
I-133		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
I-134		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
I-135		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
In-111	Indium (49)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
In-113m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
In-114m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
In-115m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ir-189	Iridium (77)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Ir-190		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Ir-192		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Ir-194		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
K-40	Potassium (19)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
K-42		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
K-43		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Kr-81	Krypton (36)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Kr-85		1.0X10 ⁵	2.7X10 ⁻⁶	1.0X10 ⁴	2.7X10 ⁻⁷
Kr-85m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ¹⁰	2.7X10 ⁻¹
Kr-87		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁹	2.7X10 ⁻²

La-137	Lanthanum (57)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
La-140		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Lu-172	Lutetium (71)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Lu-173		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Lu-174		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Lu-174m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Lu-177		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Mg-28	Magnesium (12)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Mn-52	Manganese (25)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Mn-53		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁹	2.7X10 ⁻²
Mn-54		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Mn-56		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Mo-93	Molybdenum (42)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁸	2.7X10 ⁻³
Mo-99		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
N-13	Nitrogen (7)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁹	2.7X10 ⁻²
Na-22	Sodium (11)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Na-24		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁵
Nb-93m	Niobium (41)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Nb-94		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Nb-95		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Nb-97		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Nd-147	Neodymium (60)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Nd-149		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ni-59	Nickel (28)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁸	2.7X10 ⁻³
Ni-63		1.0X10 ⁵	2.7X10 ⁻⁶	1.0X10 ⁸	2.7X10 ⁻³
Ni-65		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Np-235	Neptunium (93)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Np-236 (short-lived)		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Np-236 (long-lived)		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Np-237 (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Np-239		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Os-185	Osmium (76)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Os-191		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Os-191m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Os-193		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Os-194		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
P-32	Phosphorus (15)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
P-33		1.0X10 ⁵	2.7X10 ⁻⁶	1.0X10 ⁸	2.7X10 ⁻³
Pa-230	Protactinium (91)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Pa-231		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Pa-233		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Pb-201	Lead (82)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Pb-202		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Pb-203		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Pb-205		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴

Pb-210 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Pb-212 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Pd-103	Palladium (46)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁸	2.7X10 ⁻³
Pd-107		1.0X10 ⁵	2.7X10 ⁻⁶	1.0X10 ⁸	2.7X10 ⁻³
Pd-109		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Pm-143	Promethium (61)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Pm-144		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Pm-145		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Pm-147		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Pm-148m		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Pm-149		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Pm-151		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Po-210	Polonium (84)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Pr-142	Praseodymium (59)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Pr-143		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Pt-188	Platinum (78)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Pt-191		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Pt-193		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Pt-193m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Pt-195m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Pt-197		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Pt-197m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Pu-236	Plutonium (94)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Pu-237		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Pu-238		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Pu-239		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Pu-240		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Pu-241		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Pu-242		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Pu-244		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Ra-223 (b)	Radium (88)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Ra-224 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Ra-225		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Ra-226 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Ra-228 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Rb-81	Rubidium (37)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Rb-83		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Rb-84		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Rb-86		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Rb-87		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Rb(nat)		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Re-184	Rhenium (75)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Re-184m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Re-186		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Re-187		1.0X10 ⁶	2.7X10 ⁻⁵	1.0X10 ⁹	2.7X10 ⁻²
Re-188		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶

Re-189		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Re(nat)		1.0X10 ⁶	2.7X10 ⁻⁵	1.0X10 ⁹	2.7X10 ⁻²
Rh-99	Rhodium (45)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Rh-101		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Rh-102		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Rh-102m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Rh-103m		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁸	2.7X10 ⁻³
Rh-105		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Rn-222 (b)	Radon (86)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁸	2.7X10 ⁻³
Ru-97	Ruthenium (44)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Ru-103		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Ru-105		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Ru-106 (b)		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
S-35	Sulphur (16)	1.0X10 ⁵	2.7X10 ⁻⁵	1.0X10 ⁸	2.7X10 ⁻³
Sb-122	Antimony (51)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁴	2.7X10 ⁻⁷
Sb-124		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Sb-125		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sb-126		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Sc-44	Scandium (21)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Sc-46		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Sc-47		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sc-48		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Se-75	Selenium (34)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Se-79		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Si-31	Silicon (14)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Si-32		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Sm-145	Samarium (62)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Sm-147		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Sm-151		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁸	2.7X10 ⁻³
Sm-153		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sn-113	Tin (50)	1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Sn-117m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sn-119m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Sn-121m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Sn-123		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Sn-125		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Sn-126		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Sr-82	Strontium (38)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Sr-85		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sr-85m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Sr-87m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Sr-89		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Sr-90 (b)		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁴	2.7X10 ⁻⁷
Sr-91		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Sr-92		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
T(H-3)	Tritium (1)	1.0X10 ⁶	2.7X10 ⁻⁵	1.0X10 ⁸	2.7X10 ⁻²

Ta-178 (long-lived)	Tantalum (73)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Ta-179		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Ta-182		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Tb-157	Terbium (65)	1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Tb-158		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tb-160		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tc-95m	Technetium (43)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tc-96		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tc-96m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Tc-97		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁸	2.7X10 ⁻³
Tc-97m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Tc-98		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tc-99		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁷	2.7X10 ⁻⁴
Tc-99m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Te-121	Tellurium (52)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Te-121m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Te-123m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Te-125m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Te-127		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Te-127m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Te-129		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Te-129m		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Te-131m		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Te-132		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Th-227	Thorium (90)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Th-228 (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Th-229 (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Th-230		1.0	2.7X10 ⁻¹¹	1.0X10 ⁴	2.7X10 ⁻⁷
Th-231		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Th-232		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
Th-234 (b)		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
Th (nat) (b)		1.0	2.7X10 ⁻¹¹	1.0X10 ³	2.7X10 ⁻⁸
Ti-44	Titanium (22)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
Tl-200	Thallium (81)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Tl-201		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Tl-202		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Tl-204		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁴	2.7X10 ⁻⁷
Tm-167	Thulium (69)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Tm-170		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Tm-171		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁸	2.7X10 ⁻³
U-230 (fast lung absorption) (b),(d)	Uranium (92)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶
U-230 (medium lung absorption) (e)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷
U-230 (slow		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁴	2.7X10 ⁻⁷

lung absorption) (f)					
U-232 (fast lung absorption) (b),(d)		1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
U-232 (medium lung absorption) (e)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-232 (slow lung absorption) (f)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-233 (fast lung absorption) (d)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-233 (medium lung absorption) (e)		1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
U-233 (slow lung absorption) (f)		1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
U-234 (fast lung absorption) (d)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-234 (medium lung absorption) (e)		1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
U-234 (slow lung absorption) (f)		1.0×10^1	2.7×10^{-10}	1.0×10^5	2.7×10^{-6}
U-235 (all lung absorption types) (b),(d),(e),(f)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-236 (fast lung absorption) (d)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-236 (medium lung absorption) (e)		1.0×10^2	2.7×10^{-9}	1.0×10^5	2.7×10^{-6}
U-236 (slow lung absorption) (f)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U-238 (all lung absorption types) (b),(d),(e),(f)		1.0×10^1	2.7×10^{-10}	1.0×10^4	2.7×10^{-7}
U (nat) (b)		1.0	2.7×10^{-11}	1.0×10^3	2.7×10^{-8}
U (enriched to 20% or less) (g)		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}
V-48	Vanadium (23)	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}
W-178	Tungsten (74)	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}
Xe-122	Xenon (54)	1.0×10^2	2.7×10^{-9}	1.0×10^9	2.7×10^{-2}

Xe-123		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁹	2.7X10 ⁻²
Xe-127		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
Xe-131m		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁴	2.7X10 ⁻⁷
Xe-133		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁴	2.7X10 ⁻⁷
Xe-135		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ¹⁰	2.7X10 ⁻¹
Y-87	Yttrium (39)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Y-88		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Y-90		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁵	2.7X10 ⁻⁶
Y-91		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁶	2.7X10 ⁻⁵
Y-91m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Y-92		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Y-93		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁵	2.7X10 ⁻⁶
Yb-169	Ytterbium (70)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁷	2.7X10 ⁻⁴
Yb-175		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Zn-65	Zinc (30)	1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Zn-69		1.0X10 ⁴	2.7X10 ⁻⁷	1.0X10 ⁶	2.7X10 ⁻⁵
Zn-69m		1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Zr-88	Zirconium (40)	1.0X10 ²	2.7X10 ⁻⁹	1.0X10 ⁶	2.7X10 ⁻⁵
Zr-93 (b)		1.0X10 ³	2.7X10 ⁻⁸	1.0X10 ⁷	2.7X10 ⁻⁴
Zr-95		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁶	2.7X10 ⁻⁵
Zr-97 (b)		1.0X10 ¹	2.7X10 ⁻¹⁰	1.0X10 ⁵	2.7X10 ⁻⁶

^a [Reserved]

^b Parent nuclides and their progeny included in secular equilibrium are listed in the following:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
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

^c [Reserved]

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

^e These values apply only to compounds of uranium that take the chemical form of UO₃, UF₄, UCl₄ 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) of this table.

^g These values apply to unirradiated uranium only.

TABLE A-3—GENERAL VALUES FOR A₁ AND A₂

Contents	A ₁		A ₂		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)
	(TBq)	(Ci)	(TBq)	(Ci)				
Only beta or gamma emitting radionuclides are known to be present	1 x 10 ⁻¹	2.7 x 10 ⁰	2 x 10 ⁻²	5.4 x 10 ⁻¹	1 x 10 ¹	2.7 x 10 ⁻¹⁰	1 x 10 ⁴	2.7 x 10 ⁻⁷
Only alpha emitting radionuclides are known to be present	2 x 10 ⁻¹	5.4 x 10 ⁰	9 x 10 ⁻⁵	2.4 x 10 ⁻³	1 x 10 ⁻¹	2.7 x 10 ⁻¹²	1 x 10 ³	2.7 x 10 ⁻⁸
No relevant data are available	1 x 10 ⁻³	2.7 x 10 ⁻²	9 x 10 ⁻⁵	2.4 x 10 ⁻³	1 x 10 ⁻¹	2.7 x 10 ⁻¹²	1 x 10 ³	2.7 x 10 ⁻⁸

TABLE A-4—ACTIVITY-MASS RELATIONSHIPS FOR URANIUM

Uranium Enrichment ¹ wt % U-235 present	Specific Activity	
	TBq/g	Ci/g
0.45	1.8 x 10 ⁻⁸	5.0 x 10 ⁻⁷
0.72	2.6 x 10 ⁻⁸	7.1 x 10 ⁻⁷
1	2.8 x 10 ⁻⁸	7.6 x 10 ⁻⁷
1.5	3.7 x 10 ⁻⁸	1.0 x 10 ⁻⁶
5	1.0 x 10 ⁻⁷	2.7 x 10 ⁻⁶
10	1.8 x 10 ⁻⁷	4.8 x 10 ⁻⁶
20	3.7 x 10 ⁻⁷	1.0 x 10 ⁻⁵
35	7.4 x 10 ⁻⁷	2.0 x 10 ⁻⁵
50	9.3 x 10 ⁻⁷	2.5 x 10 ⁻⁵
90	2.2 x 10 ⁻⁶	5.8 x 10 ⁻⁵
93	2.6 x 10 ⁻⁶	7.0 x 10 ⁻⁵
95	3.4 x 10 ⁻⁶	9.1 x 10 ⁻⁵

¹ The figures for uranium include representative values for the activity of the uranium-234 that is concentrated during the enrichment process.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

G.O.C. STAFF RULE ABSTRACT

DEPARTMENT: Environment and Conservation
DIVISION: Radiological Health
SUBJECT: Rule Reorganization
STATUTORY AUTHORITY: Tennessee Code Annotated, Section 68-202-101 et seq.
EFFECTIVE DATES: May 22, 2012 through June 30, 2013
FISCAL IMPACT: Minimal
STAFF RULE ABSTRACT:

These rulemaking changes reflect a reorganization of all TDEC rules in order to be more logical and user friendly. This rulemaking affects Chapters 1200-02-04, 1200-02-05, 1200-02-06, 1200-02-07, 1200-02-08, 1200-02-09, 1200-02-10, 1200-02-11 and 1200-02-12. Its various additions and modifications will incorporate:

- a. Changes to the numbering designation of Radiological Health rules from 1200-02 to 0400-20;
- b. Correcting typographical errors throughout all Chapters; and
- c. Deleting obsolete language.

Public Hearing Comments

One copy of a document containing responses to comments made at the public hearing must accompany the filing pursuant to T.C.A. §4-5-222. Agencies shall include only their responses to public hearing comments, which can be summarized. No letters of inquiry from parties questioning the rule will be accepted. When no comments are received at the public hearing, the agency need only draft a memorandum stating such and include it with the Rulemaking Hearing Rule filing. Minutes of the meeting will not be accepted. Transcripts are not acceptable.

No comments were received during the comment period.

Regulatory Flexibility Addendum

Pursuant to T.C.A. § 4-5-401 through 4-5-404, prior to initiating the rule making process as described in T.C.A. § 4-5-202(a)(3) and T.C.A. § 4-5-202(a), all agencies shall conduct a review of whether a proposed rule or rule affects small businesses.

(If applicable, insert Regulatory Flexibility Addendum here)

- (1) The type or types of small business and an identification and estimate of the number of small businesses subject to the proposed rule that would bear the cost of, or directly benefit from the proposed rule:

This rulemaking that changes the rule numbers from Chapter 1200-20-06 and that makes other housekeeping changes makes no substantive changes. Therefore, there is no impact on small business.

- (2) The projected reporting, recordkeeping, and other administrative costs required for compliance with the proposed rule, including the type of professional skills necessary for preparation of the report or record:

There are no projected additional reporting, recordkeeping or administrative costs as a result of this rulemaking.

- (3) A statement of the probable effect on impacted small businesses and consumers:

There is no expected adverse affect on small businesses as a result of this rulemaking.

- (4) A description of any less burdensome, less intrusive or less costly alternative methods of achieving the purpose and objectives of the proposed rule that may exist, and to what extent the alternative means might be less burdensome to small business:

The Department is unaware of alternatives to the proposed rules.

- (5) A comparison of the proposed rule with any federal or state counterparts:

There is no exact match with any federal or state counterparts.

- (6) Analysis of the effect of the possible exemption of small businesses from all or any part of the requirements contained in the proposed rule.

Due to the administrative nature of this rulemaking small businesses could not be exempt from this rulemaking.

Impact on Local Governments

Pursuant to T.C.A. 4-5-220 and 4-5-228 "any rule to proposed to be promulgated shall state in a simple declarative sentence, without additional comments on the merits of the policy of the rules or regulation, whether the rule or regulation may have a projected impact on local governments." (See Public Chapter Number 1070 (<http://state.tn.us/sos/acts/106/pub/pc1070.pdf>) of the 2010 Session of the General Assembly)

The Department does not anticipate that these amended rules will have a financial impact on local governments.

Department of State
Division of Publications
 312 Rosa L. Parks Avenue, 8th Floor Snodgrass/TN Tower
 Nashville, TN 37243
 Phone: 615-741-2850
 Fax: 615-741-5133
 Email: register.information@tn.gov

For Department of State Use Only

Sequence Number: PEDLINE
 Rule ID(s): _____
 File Date: _____
 Effective Date: _____

Rulemaking Hearing Rule(s) Filing Form

Rulemaking Hearing Rules are rules filed after and as a result of a rulemaking hearing. TCA Section 4-5-205.

Agency/Board/Commission:	Environment and Conservation
Division:	Radiological Health
Contact Person:	Beth Murphy
Address:	3 rd Floor L&C Annex 401 Church Street Nashville, Tennessee
Zip:	37243-1532
Phone:	(615) 532-0392
Email:	beth.murphy@tn.gov

Revision Type (check all that apply):

- Amendment
 New
 Repeal

Rule(s) Revised (ALL chapters and rules contained in filing must be listed here. If needed, copy and paste additional tables to accommodate multiple chapters. Please enter only ONE Rule Number/Rule Title per row)

Chapter Number	Chapter Title
0400-20-06	Use of X-Ray Apparatus
Rule Number	Rule Title
0400-20-06-.01	Purpose
0400-20-06-.02	Scope
0400-20-06-.03	Definitions
0400-20-06-.04	General Safety Precautions
0400-20-06-.05	Medical X-Ray Installations
0400-20-06-.06	Veterinary X-Ray Installations
0400-20-06-.07	Analytical X-Ray Installations
0400-20-06-.08	X-Ray Gauges
0400-20-06-.09	Appendix A

Chapter Number	Chapter Title
1200-02-06	Use of X-Ray Apparatus
Rule Number	Rule Title
1200-02-06-.01	Purpose
1200-02-06-.02	Scope
1200-02-06-.03	Definitions
1200-02-06-.04	General Safety Precautions
1200-02-06-.05	Medical X-Ray Installations
1200-02-06-.06	Veterinary X-Ray Installations
1200-02-06-.07	Analytical X-Ray Installations
1200-02-06-.08	X-Ray Gauges
1200-02-06-.09	Appendix A

(Place substance of rules and other info here. Statutory authority must be given for each rule change. For information on formatting rules go to <http://tn.gov/sos/rules/1360/1360.htm>)

Repeal

Chapter 1200-02-06 Use of X-Ray Apparatus is repealed.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq., and 4-5-201 et seq.

New Rules

Chapter 0400-20-06 Use of X-Ray Apparatus

Table of Contents

0400-20-06-.01 Purpose	0400-20-06-.06 Veterinary X-Ray Installations
0400-20-06-.02 Scope	0400-20-06-.07 Analytical X-Ray Installations
0400-20-06-.03 Definitions	0400-20-06-.08 X-Ray Gauges
0400-20-06-.04 General Safety Precautions	0400-20-06-.09 Appendix A
0400-20-06-.05 Medical X-Ray Installations	

~~1200-02-06-.01~~ 0400-20-06-.01 Purpose.

This Chapter establishes requirements for the use of x-ray apparatus, except industrial radiography. The provisions of this Chapter are in addition to and not in substitution for other applicable provisions of these regulations.

Authority: T.C.A. §§ 68-202-101 et seq. and 4-5-201 et seq.

~~1200-02-06-.02~~ 0400-20-06-.02 Scope.

Except as otherwise specifically provided, this chapter applies to all uses of x-ray apparatus in the healing arts, veterinary medicine, industry and educational institutions.

Authority: T.C.A. §§ 68-202-101 et seq. and 4-5-201 et seq.

~~1200-02-06-.03~~ 0400-20-06-.03 Definitions.

- (1) "Accessible surface" means ~~T~~the external surface of the enclosure or housing provided by the manufacturer.
- (2) "Added filter" means ~~T~~the filter added to the inherent filtration.
- (3) "Aluminum equivalent" means ~~T~~the thickness of aluminum (Type 1100 alloy)¹ affording the same attenuation, under specified conditions, as the material in question.
- (4) "Analytical x-ray equipment" means ~~A~~any device that utilizes x-rays for the purpose of examining the microstructure of materials.
- (5) "Attenuation block" means ~~A~~a block or stack, having dimensions 20 cm by 20 cm by 3.8 cm, or type 1100 aluminum alloy¹ or other materials having equivalent attenuation.
- (6) "Automatic exposure control" means ~~A~~a device that automatically controls one or more technique factors in order to obtain at a pre-selected location(s) a required quantity of radiation.
- (7) "Beam axis" means ~~A~~a line from the source through the centers of the x-ray fields.

¹ The nominal chemical composition of type 1100 aluminum alloy is 99.00 percent minimum aluminum, 0.12 percent copper. "Aluminum – Standards and Data," The Aluminum Association, New York, New York. (1969).
SS-7039 (July 2010) 2 RDA 1693

- (8) "Beam-limiting device" means Aa device that provides a means to restrict the dimensions of the x-ray field.
- (9) "Certified components" means G components of diagnostic x-ray systems that are subject to regulations promulgated under P.L. 90-602.
- (10) "Collimator" means Aa device or mechanism by which the x-ray beam is restricted in size.
- (11) "Control panel" means F that part of the x-ray control upon which are mounted the switches, knobs, pushbuttons, and other hardware necessary for manually setting the technique factors.
- (12) "Contact therapy apparatus" means M x-ray apparatus designed for therapy at very short treatment distances, 5 centimeters or less, usually employing tube potentials in the range of 20 to 50 kVp.
- (13) "Dead-man switch" means Aa switch so constructed that a circuit closing contact can be maintained only by continuous pressure on the switch by the operator.
- (14) "Diagnostic source assembly" means F the tube housing assembly with a beam limiting device attached.
- (15) "Diagnostic type tube housing" means X x-ray tube housing so constructed that at a distance of 1 meter from the target, the leakage cannot exceed 100 milliroentgens in 1 hour when the tube is operated at its maximum continuous rated current for the maximum rated tube potential. An acceptable method for the determination of the maximum leakage from an x-ray tube is to take measurements at 8 compass points in each of the 3 planes at right angles to each other at 1 meter from the target with the useful beam blocked with ten half-value layers (HVL) of attenuating material.
- (16) "Diagnostic x-ray system" means Aa an x-ray system designed for irradiation of any part of the human body for the purpose of diagnosis or visualization.
- (17) "Diaphragm" means Aa device or mechanism by which the x-ray beam is restricted in size.
- (18) "Entrance exposure rate" means F the roentgens per minute at the point where the center of the useful beam enters the patient.
- (19) "Equipment" means X x-ray equipment.
- (20) "Fail-safe design" means G one in which all failures of indicator of safety components that can reasonably be anticipated cause the equipment to fail in a mode such that personnel are safe from exposure to radiation. For example: (a) if a light indicating X-RAY ON fails, the production of x-rays shall be prevented, and (b) if a shutter status indicator fails, the shutter shall close.
- (21) "Field emission equipment" means E equipment that uses an x-ray tube in which electron emission from the cathode is due solely to the action of an electric field.
- (22) "Filter" means M material placed in the useful beam to absorb preferentially the less penetrating radiations.
- (23) "Fluoroscopic imaging assembly" means Aa component that comprises a reception system in which x-ray photons produce a fluoroscopic image. It includes equipment housing, electrical interlocks if any, the primary protective barrier, and structural material providing linkage between the image receptor and the diagnostic source assembly.
- (24) "General purpose radiographic x-ray system" means Aa any radiographic x-ray system that, by design, is not limited to radiographic examination of specific anatomical regions.
- (25) "Gonadal shield" means M a protective barrier for the gonads.
- (26) "Half-value layer" (HVL) means F thickness of an absorber required to reduce a beam of radiation to one-half its incident exposure rate.

- (27) "Image intensifier" ~~M~~means a device that converts instantaneously by means of photo-emissive surfaces and electronic circuitry an x-ray pattern into a light pattern of greater intensity than would have been produced by the original x-ray pattern.
- (28) "Image receptor" ~~M~~means any device, such as a "fluorescent screen or radiographic film," that transforms incident x-ray photons either into a visible image or into another form that can be made into a visible image by further transformations.
- (29) "Inherent filtration" ~~means~~ ~~T~~the filtration permanently in the useful beam; it includes the window of the x-ray tube and any permanent tube or source enclosure.
- (30) "Kilovolts peak" (kVp) ~~means~~ ~~T~~the crest value in kilovolts of the potential difference of a pulsating potential generator. When only one-half of the wave is used, the value refers to the useful half of the wave.
- (31) "kWs" ~~means~~ ~~K~~kilowatt second which is equal to the product of kilovolts, amperes, and seconds or 10^3 kVp.mA.sec.
- (32) "Lead equivalent" ~~means~~ ~~T~~the thickness of lead affording the same attenuation, under specified conditions, as the material in question.
- (33) "Leakage radiation" ~~means~~ ~~R~~radiation emanating from the diagnostic source assembly except for:
- (a) The useful beam and
 - (b) Radiation produced when the exposure switch or timer is not activated.
- (34) "Leakage technique factors" ~~means~~ ~~T~~the technique factors associated with the tube housing assembly that are used in measuring leakage radiation. They are defined as follows:
- (a) For capacitor energy storage equipment, the maximum rated number of exposures in an hour for operation at the maximum rated peak tube potential with the quantity of charge per exposure being 10 millicoulombs (mAs) or the minimum obtainable from the unit, whichever is larger.
 - (b) For field emission equipment rated for pulsed operation, the maximum rated number of x-ray pulses in an hour for operation at the maximum rated peak tube potential.
 - (c) For all other equipment, the maximum rated continuous tube current for the maximum rated peak tube potential.
- (35) "Light field" ~~means~~ ~~T~~that area of the intersection of the light beam from the beam-limiting device and one of the set of planes parallel to and including the plane of the image receptor, whose perimeter is the locus of points at which the illumination is one-fourth of the maximum in the intersection.
- ~~(74)(36)~~ "Misadministration" ~~means~~ ~~A~~an event that meets the criteria in ~~1200-02-05-145~~ Rule 0400-20-05-145.
- ~~(36)(37)~~ "Mobile equipment". See "X-ray equipment".
- ~~(37)(38)~~ "Multipurpose radiographic equipment" ~~means~~ ~~A~~an x-ray machine designed or used for radiographic examinations of more than one part of the body, or one designed or used for both diagnosis and therapy.
- ~~(38)(39)~~ "Normal operation" ~~means~~ ~~O~~operation under conditions suitable for collecting data as recommended by a manufacturer of the x-ray system. Recommended shielding and barriers shall be in place.
- ~~(39)(40)~~ "Open beam x-ray equipment" ~~means~~ ~~A~~an analytical x-ray producing device designed in such a way that the primary beam is not completely enclosed by the tube housing-apparatus complex during normal operation.
- ~~(40)(41)~~ "Phototimer" ~~means~~ ~~A~~a method for timing radiation exposures to image receptors by the amount of

radiation that reaches a sensitive photo tube behind the receptor and that provides a means for precisely reproducing densities on these receptors.

(41)(42) "Primary beam". See "Useful beam" as defined in Rule ~~1200-02-04-04~~ 0400-20-04-04.

(42)(43) "Peak tube potential" means ~~T~~ the maximum value of the potential difference across the x-ray tube during an exposure.

(43)(44) "Portable equipment". See "X-ray equipment".

(44)(45) "Position indicating device" (PID) means ~~A~~ a device on dental x-ray equipment used to indicate the beam position and to establish a definite source-surface (skin) distance. It may or may not incorporate or serve as a beam-limiting device.

(45)(46) "Protective apron" means ~~an~~ an apron made of radiation absorbing materials equivalent to at least 0.25 millimeters of lead used to reduce radiation.

(46)(47) "Protective glove" means ~~a~~ a glove made of radiation absorbing materials equivalent to at least 0.25 millimeters of lead used to reduce radiation exposure.

(47)(48) "Qualified individual" means ~~An~~ an individual who has demonstrated to the satisfaction of the Division that he possesses the knowledge and training to measure ionizing radiation, to evaluate safety techniques and to advise regarding radiation protection needs.

(48)(49) "Radiograph" means ~~A~~ a permanent picture or image produced on a sensitive surface by a form of radiation other than visible light.

(49)(50) "Rating" means ~~T~~ the operating limits as specified by the original component manufacturer.

(50)(51) "Recording" means ~~P~~ producing a permanent form of an image resulting from x-ray photons (e.g., film, video tape).

(51)(52) "Scattered radiation" means ~~R~~ radiation that, during passage through matter, has been deviated in direction. It may also have been modified by a decrease in energy.

(52)(53) "Shutter" means ~~An~~ an adjustable device, generally of lead, fixed to an x-ray tube housing to intercept or collimate the useful beam.

(53)(54) "Source" means ~~T~~ the focal spot of the x-ray tube.

(54)(55) "Source-image receptor distance" (SID) means ~~T~~ the distance from the source to the center of the input surface of the image receptor.

(55)(56) "Stationary equipment". See "X-ray equipment".

(56)(57) "Stray radiation" means ~~T~~ the sum of leakage and scattered radiation.

(57)(58) "Technique factors" means ~~T~~ the conditions of operation. They are specified as follows:

- (a) For capacitor energy storage equipment, peak tube potential in kV and quantity of charge in mAs.
- (b) For field emission equipment rated for pulsed operation, peak tube potential in kV and number of x-ray pulses.
- (c) For all other equipment, peak tube potential in kV and either tube current in mA and exposure time in seconds, or the product of the tube current and exposure time in mAs.

(58)(59) "Total filter" means ~~T~~ the sum of the inherent and added filters.

- ~~(59)~~(60) "Tube" means An x-ray tube, unless otherwise specified.
- ~~(60)~~(61) "Tube housing-apparatus complex" means Those parts of an analytical x-ray device in which x-rays are produced and utilized.
- ~~(61)~~(62) "Tube housing assembly" means The tube housing with tube installed. It includes high-voltage and/or filament transformers and other appropriate elements when they are contained within the tube housing.
- ~~(62)~~(63) "Tube rating chart" means The set of curves that specify the rated limits of operation of the tube in terms of the technique factors.
- ~~(63)~~(64) "Variable-aperture beam-limiting device" means Aa beam limiting device that has capacity for stepless adjustment of the x-ray field size at given SID.
- ~~(64)~~(65) "Visible area" means That portion of the input surface of the image receptor over which incident x-ray photons are producing a visible image.
- ~~(65)~~(66) "X-ray apparatus" means Any device for the production of x-rays.
- ~~(66)~~(67) "X-ray control" means Aa device that controls input power to the x-ray high-voltage generator and/or the x-ray tube. It includes equipment that controls the technique factors of the x-ray exposure.
- ~~(67)~~(68) "X-ray equipment" means An x-ray system, subsystem, or component thereof.
- (a) Mobile means x-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.
 - (b) Portable means x-ray equipment designed to be hand-carried.
 - (c) Stationary means x-ray equipment that is installed in a fixed location.
 - (d) Transportable means x-ray equipment to be installed in a vehicle or that may be readily disassembled for transport in a vehicle.
- ~~(68)~~(69) "X-ray field" means That area of the intersection of the useful beam and any one of the set of planes parallel to and including the plane of the image receptor whose perimeter is the locus of points at which the exposure rate is one-fourth of the maximum in the intersection.
- ~~(69)~~(70) "X-ray high-voltage generator" means Aa device that transforms electrical energy from the potential supplied by the x-ray control to the tube operating potential. The device may also include direct current, filament transformers for the x-ray tube(s), high-voltage switches, electrical protective devices, and other appropriate elements.
- ~~(70)~~(71) "X-ray gauge" means An x-ray producing device designed and manufactured for the purpose of detecting, measuring, gauging, or controlling thickness, density, level, or interface location.
- ~~(71)~~(72) "X-ray system" means An assemblage of components for the controlled production of x-rays. It includes minimally an x-ray high-voltage generator, an x-ray control, a tube housing assembly, a beam-limiting device, and the necessary supporting structures. Additional components that function with the system are considered integral parts of the system.
- ~~(72)~~(73) "X-ray subsystem" means Any combination of two or more components of an x-ray system for which there are requirements specified in this Chapter.
- ~~(73)~~(74) "X-ray tube" means Any electron tube that is designed for the conversion of electrical energy into x-ray energy.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq. and 4-5-201 et seq.

~~1200-02-06-04~~ ~~0400-20-06-04~~ General Safety Precautions.

- (1) No person shall make, sell, lease, transfer, lend, repair, or install x-ray equipment or the supplies used in connection with such equipment unless such supplies or equipment, when properly placed in operation and properly used, will meet the requirements of these regulations. This includes but is not limited to such items as cones, collimators, filters, adequate timers, and fluoroscopic shutters (where applicable). Also, such person shall be registered with the Division pursuant to ~~1200-02-10-24~~ Rule 0400-20-10-24.
- (2) Unless otherwise specified, each installation shall be provided with such primary barriers and/or secondary barriers as are necessary to assure compliance with ~~1200-02-05-50~~ Rule 0400-20-05-50, ~~1200-02-05-55~~ 0400-20-05-55, ~~1200-02-05-56~~ 0400-20-05-56 or ~~1200-02-05-60~~ 0400-20-05-60, whichever applies.
- (3) No registrant shall operate or permit the operation of x-ray equipment unless the equipment and installation meets the requirements of these regulations.
- (4) The registrant shall assure that all x-ray apparatus under his control is operated only by individuals instructed in safe operating procedures and competent in safe use of the apparatus.
- (5) Except for medical and dental units, no x-ray apparatus shall be left unattended or unsecured unless the control switch is turned "off," the power to the control switch disconnected, or the room, x-ray apparatus, or area housing the x-ray apparatus is locked.
- (6) Film development procedures recommended by the film manufacturer or other tested procedures shall be followed, which will insure maximum information content of the processed film with minimum radiation exposure. Except where automatic processors are used, it is required that an operable timer and thermometer be available and used for darkroom procedures. Darkrooms shall be light tight and shall contain safelights designed for the film being used.
- (7) The effectiveness of protective equipment shall not be impaired.
- (8) X-ray producing devices and associated equipment shall be maintained in such a condition as to ensure that the patient and attendants are not exposed to radiation unnecessarily.
- (9) The Division may waive compliance with the specific requirements of this Rule for an existing x-ray apparatus or installation if:
 - (a) Such compliance would require replacement or substantial modification of the x-ray apparatus or installation; and,
 - (b) The registrant demonstrates, to the Division's satisfaction, achievement through other means, of radiation protection equivalent to that required by these regulations.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq. and 4-5-201 et seq.

~~1200-02-06-05~~ 0400-20-06-05 Medical X-Ray Installations.

- (1) Therapeutic x-ray installations.
 - (a) Requirements for equipment and facility:
 1. The tube housing shall be of the therapeutic type.
 2. Adjustable beam limiting diaphragms, cones, or fixed diaphragms shall be provided to collimate the useful beam to the area under treatment.
 3. Fixed diaphragms or cones used to collimate the useful beam shall be so constructed as to provide the same degree of protection as the tube housing.
 4. Adjustable beam limiting diaphragm or cones shall not transmit more than 5 percent of the useful beam at the maximum kilovoltage and with the maximum treatment filter.

5. The radiation escaping through the filter slots shall not exceed an exposure rate of 1 R/hr at a distance of 1 meter or if the radiation from the slot is accessible to the patient, 30 R/hr at 5 centimeters from the external opening. Each removable filter shall be marked with its thickness and material.
6. The x-ray tube shall be secured so that it cannot move in respect to the aperture. A mark on the housing shall show the location of the focal spot.
7. A device shall be provided to immobilize the tube housing during stationary portal treatment.
8. A device shall be provided to terminate the exposure automatically after a preset time interval or preset exposure or dose limit. Means shall be provided for the operator to terminate the exposure at any time.
9. A filter indicator system shall be used on all therapy x-ray apparatus using changeable filters. It shall indicate from the control panel the presence or absence of any filter and it shall be designed to permit recognition of the filter in place. Color coded filters that are visible from the control panel qualify as an adequate indicator system.
10. Interlocks shall be provided so that when any door of the treatment room is opened either the x-ray apparatus will shut off automatically or the radiation exposure level within the room will be reduced to an average of not more than 2 milliroentgens per hour and an maximum of 10 milliroentgens per hour at a distance of 1 meter in any direction from the target. After such shut-off or reduction in output it shall be possible to restore the x-ray apparatus to full operation only from the control panel. For equipment operating at or below 60 kVp interlocks are not required.
11. The treatment room shall be so constructed that persons within the room may at all times be able to escape.
12. A visible signal which is actuated during the time x-rays are being generated shall be located outside and near each door to the treatment room.
13. There shall be on the control panel a device which indicates to the operator whether or not the tube is energized.
14. In the therapeutic use of x-ray apparatus constructed with windows of beryllium, or other material having an aluminum equivalent half-value layer less than 0.5 millimeter, the registrant shall use extreme care to insure that the unfiltered radiation reaches only that area of the patient intended and that the beam port is blocked at all times except when actually being used.
15. For contact therapy apparatus, the leakage radiation exposure at 5 centimeters from the surface of the tube housing shall not exceed 100 milliroentgens per hour.

(b) Conditions of operation:

1. The output of each therapeutic x-ray apparatus shall be calibrated by a qualified individual. The calibration shall be repeated after any change in or replacement of components of the x-ray generating equipment that could cause a change in x-ray output. Check calibrations shall be made at least once a year thereafter. Records of all calibrations shall be maintained by the registrant for inspection by the Division.
2. When a patient must be held in position for radiation therapy, mechanical supporting or restraining devices shall be used whenever feasible. If the patient must be held by an individual, the individual shall wear a protective apron and he shall be positioned so that no part of his body will be struck by the useful beam and his body is as far as possible from the edge of the useful beam and his exposure shall be monitored and a record of

such monitoring maintained for inspection by the Division. No pregnant women or persons under 18 years of age shall be used for this purpose.

3. Both the patient and control panel shall be under observation by the operator during patient irradiation.
4. All new installations and existing installations not previously surveyed shall have a radiation survey made by a qualified individual or registered inspector for the applicable class of x-ray unit. This shall be done after any change in the installation that might produce radiation levels in excess of those permitted by these regulations. Inadequacies found during the survey shall be corrected. A record of these surveys shall be kept on file for inspection by the Division.
5. Lead rubber, lead foil, or any other material used for limiting the treatment field shall transmit not more than ~~five~~ 5 percent of the useful beam as measured when the maximum treatment filter for which the x-ray unit has been calibrated is in place.
6. Provision shall be made for oral communication with the patient from the control area.
7. No one other than the patient shall be in treatment room during treatment except as allowed in ~~4200-02-06-05(1)(b)~~ part 2 of this subparagraph except that for equipment operating at or below 60 kVp the operator and other persons may be permitted in the room during treatment provided that all such persons utilize protective aprons or their equivalent.

(2) Medical diagnostic x-ray installations.

(a) General requirements. Equipment:

1. The primary beam shall not be larger than clinically necessary. Cones, diaphragms, or adjustable collimators capable of restricting the primary beam to the area of clinical interest or an area within the limits imposed by the following conditions, whichever area is smaller, shall be used. The x-ray field size in the plane of the image receptor, whether controlled by cones, diaphragms, or adjustable collimators shall be such that neither the length nor the width of the x-ray field exceeds that of the image receptor by greater than 3 percent of the source-image receptor distance (SID) and that the sum of the length and width excesses be no greater than 4 percent of the SID when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor². Cones, diaphragms, or adjustable collimators used to restrict the primary beam shall provide the same degree of protection as is required in the tube housing.
2. (i) Except when contraindicated for a particular diagnostic procedure, the aluminum equivalent of the total filtration (inherent plus added) in the useful beam shall not be less than that shown in Table RHS 3-1.

Table RHS 3-1 FILTRATION REQUIRED VS. OPERATING VOLTAGE

Operating voltage (kVp)	Total filtration (millimeters) Al equivalent
Below 50	0.5
50 - 70	1.5
Above 70	2.5

- (ii) If the thickness of the filter in the x-ray apparatus cannot be determined visually or the total filtration is unknown, it may be assumed that the requirements of

² For purposes of these regulations the length and width measurements will be made through the center of the x-ray field. The length measurement will be made at an angle of 90 degrees to the width measurement. Thus for circular beams the length and width will be equal to the diameter.

(2)(a)2 subpart (i) of this Rule part are met if the half-value layer is not less than that shown in Table RHS 3-2.

Table RHS 3-2 HALF-VALUE LAYER VS. OPERATING VOLTAGE

Design operating range (kilovolts peak) (kVp)	Measured potential (kVp)	Half-value layer (millimeters of aluminum)
Below 50	30	0.3
	40	0.4
	49	0.5
50 to 70	50	1.2
	60	1.3
	70	1.5
Above 70	71	2.1
	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

- (iii) For capacitor energy storage equipment, compliance shall be determined with the maximum quantity of charge per exposure.
 - (iv) For fluoroscopic equipment, the HVL measurement shall include the filtration contributed by the tabletop if the tabletop is placed permanently between the patient and the source.
3. The x-ray tube housing shall be of diagnostic type.
 4. The leakage radiation from the diagnostic source assembly measured at a distance of 1 meter in any direction from the source shall not exceed 100 milliroentgens in 1 hour when the x-ray tube is operated at its leakage technique factors. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.
 5. The radiation emitted by a component other than the diagnostic source assembly shall not exceed 2 milliroentgens in 1 hour at 5 centimeters from any accessible surface of the component when it is operated in an assembled x-ray system under any conditions for which it was designed. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.
 6. Hand or head held fluoroscopic screens shall not be used.
 7. Machines equipped with beryllium window x-ray tubes shall contain keyed filter interlock switches in the tube housing that activate a device on the control panel that indicates the added filter in the useful beam if the total filtration permanently in the useful beam is less than 0.5 millimeter aluminum equivalent. The total filtration permanently in the useful beam shall be indicated on the tube housing.
 8. Beryllium window x-ray tubes shall not be used on multi-purpose radiographic equipment.
 9. On battery-powered generators, visual means shall be provided on the control panel to indicate whether the battery is in a state of charge adequate for proper operation.

10. On installations made after March 1, 1978, where two or more tubes are controlled by one exposure switch, the tube or tubes that have been selected shall be clearly indicated prior to initiation of the exposure. This indication shall be both on the x-ray control and at or near the tube housing assembly that has been selected.
 11. (Reserved)
 12. Tube housing assemblies shall be equipped with a means to assure mechanical support of the housing during exposures without drift or vibration.
 13. Where cones or diaphragms are used as beam limiting devices, each such device shall have clear and permanent markings to indicate the image receptor size and SID for which it is designed.
 14. In addition to other applicable requirements of this Chapter, diagnostic x-ray equipment certified under the Federal standards promulgated by the Department of Health and Human Services, in the Federal Register shall meet the following requirements:
 - (i) Each registrant shall retain, and shall present to the Division for examination when requested, all information provided by the manufacturer to the purchaser in accordance with the requirements of the applicable Federal standard and shall transfer this information to the subsequent owner of the equipment. See Rule 0400-20-06-09, APPENDIX A, Chapter 1200-02-06.
 - (ii) Each registrant should keep a record of all maintenance and modifications performed on each diagnostic x-ray system containing any components certified under the applicable Federal standard during the period it is under his control, and, if kept, shall be transferred to the subsequent owner of the equipment.
 - (iii) No deviation from the requirements of these regulations will be considered a violation of these regulations if such deviation is permitted by a variance granted by the Food and Drug Administration, Department of Health and Human Services, or by a regulation promulgated pursuant to Public Law 90-602.
- (b) General requirements. Operation of equipment:
1. Patient or film holding
 - (i) Except where clinically contraindicated, restraining devices or mechanical supporting devices shall be used.
 - (ii) No person under eighteen (18) years of age and no pregnant women shall be used.
 - (iii) No individual shall be used on a consistent or routine basis.
 - (iv) Protective gloves and aprons with at least 0.25 millimeters of lead equivalency shall be provided and their use required of each person used for this purpose.
 - (v) No part of the body of the person utilized for this purpose shall be in the primary beam unless protected by 0.5 millimeter of lead equivalent material.
 - (vi) If occupationally exposed persons are utilized their exposure shall be monitored.
 2. Gonadal protection, by use of gonadal shields, shall be provided and used for patients who have not passed the reproductive age, during each radiographic procedure in which the gonads are in the useful beam or proximate thereto, except for those cases in which the shield would interfere with the diagnostic procedure. The protection provided shall be at least equivalent to 0.25 millimeters of lead.

3. Other than the patient being examined no one will be allowed in the room during the radiographic exposure unless:
 - (i) The location of all individuals in the room shall be such that no part of the body including the extremities not protected by 0.5 millimeter lead equivalent will be struck by the useful beam.
 - (ii) Staff and ancillary personnel shall be protected from the direct scatter radiation by protective aprons or whole body protective barriers of not less than 0.25 millimeters lead equivalent.
 - (iii) Other patients in the room shall be protected from the direct scatter radiation by whole body protective barriers of 0.25 millimeters lead equivalent or shall be so positioned that the nearest portion of the body is at least two 2 meters from both the tube head and the nearest edge of the image receptor.

(c) Radiographic Installations (includes photofluorographic units)

1. The operator shall be able to see the patient and the control panel at all times during an exposure.
2. Radiographic equipment equipped with adjustable collimators shall contain light localizers that define the entire x-ray field. The size of the light field in the plane of the image receptor shall be such that no dimension of the light field differs from that of the x-ray field by greater than two 2 percent of the SID when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor. The center of the light field shall be aligned with the center of the x-ray field to within two 2 percent of the SID when the equipment indicates that the beam axis perpendicular to the plane onto which the x-ray and light fields are projected. See ~~1200-02-06-05~~ part (2)(a)1 of this rule for definition of length and width. The collimator shall also be equipped with a field size indicator that indicates numerically the dimensions of the x-ray field at the source-image receptor distances (SIDs) for which it is designed. Such numerical indication shall not deviate from the actual dimensions of the x-ray field at the SID by more than two 2 percent of the SID when the equipment indicates that the axis of the beam is perpendicular to the plane of the image receptor. For equipment utilized in a manner that precludes the necessity of numerical indicators they shall not be required.
3. (Reserved)
4. Radiographic equipment designed for only one image receptor size at a fixed SID shall be provided with means to limit the field at the plane of the image receptor to dimensions no greater than those of the image receptor, and to align the center of the x-ray field with the center of the image receptor to within two 2 percent of the SID.
5. Radiation Exposure Control Devices.
 - (i) Timers

Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor.

 - (I) Termination of exposure shall cause automatic resetting of the timer to its initial setting or to zero.
 - (II) It shall not be possible to make an exposure when the timer is set to a zero or off position if either position is provided.
 - (ii) X-Ray Control

- (I) A control shall be incorporated into each x-ray system such that an exposure can be terminated at any time except for:
 - I. Exposure of one-half second or less, or
 - II. During serial radiography when means shall be provided to permit completion of any single exposure of the series in process.
- (II) Each x-ray control shall be located in such a way as to meet the following criteria:
 - I. For stationary x-ray systems, the control shall be permanently mounted in a protected area so that the operator is required to remain in that protected area during the entire exposure; or
 - II. For mobile and portable x-ray systems, a method of control shall be provided that will permit the operator to stand at least 2 meters from the patient, primary beam, and tube head assembly.
- (iii) Automatic Exposure Controls (Phototimers). When an automatic exposure control is provided:
 - (I) A device shall be on the control panel that indicates when this mode of operation is selected;
 - (II) When the x-ray tube potential is equal to or greater than 50 kVp, the minimum exposure time for field emission equipment rated for pulsed operation shall be equal to or less than a time interval equivalent to ~~two~~ 2 pulses;
 - (III) The minimum exposure time for all other equipment shall be equal to or less than 1/60 second or a time interval required to deliver 5 mAs, whichever is greater;
 - (IV) Either the product of peak x-ray tube potential, current, and exposure time shall be limited to not more than 60 kW per exposure or the product of x-ray tube current and exposure time shall be limited to not more than 600 mAs per exposure except when the x-ray tube potential is less than 50 kVp in which case the product of x-ray tube current and exposure time shall be limited to not more than 2000 mAs per exposure; and
 - (V) A visible signal shall indicate when an exposure has been terminated at the limits described in item (IV) of this subpart, and manual resetting shall be required before further automatically timed exposures can be made.
- (iv) The exposure shall be reproducible. When ~~four~~ 4 exposures are made at identical technique factors the value of the average exposure (\bar{E}) shall be greater than or equal to 5 times the difference between the maximum exposure (E_{max}) and the minimum exposure (E_{min}), i.e.,

$$\bar{E} \geq 5 (E_{max} - E_{min}).$$
- (v) The timer shall be reproducible. When ~~four~~ 4 timer tests are performed with a timer setting of 0.5 seconds or less, the average time period (\bar{T}) shall be

greater than or equal to 5 times the difference between the maximum period (T_{\max}) and the minimum period (T_{\min}), i.e.,

$$\bar{T} \geq 5 (T_{\max} - T_{\min}).$$

6. Radiation emitted from the x-ray tube of Capacitor Energy Storage Equipment when the exposure switch or timer is not activated shall not exceed a rate of 2 milliroentgens per hour at 5 centimeters from any accessible surface of the diagnostic source assembly, with the beam-limiting device fully open.
7. For stationary general purpose x-ray systems means shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor, to align the center of the x-ray field with respect to the center of the image receptor to within 2 percent of the SID, and to indicate the SID to within 2 percent.

(d) Fluoroscopic installations

1. The source to skin distance shall not be less than 30.5 centimeters on stationary equipment installed or reinstalled before July 1, 1972, and shall not be less than 38 centimeters on stationary equipment installed or reinstalled thereafter. The source to skin distance shall not be less than 30.5 centimeters on all mobile fluoroscopes. For image intensified fluoroscopes used for specific surgical applications a source to skin distance of 20 centimeters will be allowed provided the user's operating procedures indicate precautionary measures to be adhered to during this device's use and provided that these precautionary measures are followed by the registrant or his representative.
2. Equipment shall be so constructed that the entire cross-section of the useful beam is attenuated by a primary barrier permanently incorporated into the equipment. The tube mounting and the barrier shall be so linked together that the barrier always intercepts the beam. This barrier is usually the viewing device, either a conventional fluoroscopic screen or an image intensification mechanism.
3. The required lead equivalent of the primary barrier shall be at least 1.5 millimeters for 100 kVp, 1.8 millimeters for 125 kVp, and 2.0 millimeters for 150 kVp. This requirement may be assumed to have been met if the exposure rate due to transmission through the barrier with the attenuation block in the useful beam combined with radiation from the image intensifier, if provided, does not exceed 2 milliroentgens per hour at 10 centimeters from any accessible surface of the fluoroscopic imaging assembly beyond the plane of the image receptor for each roentgen per minute of entrance exposure rate³.
4. Collimators shall be provided to restrict the size of the useful beam to less than the area of the primary barrier. For conventional fluoroscopes, this requirement is met if, when the adjustable diaphragm is opened to its fullest extent, an unilluminated margin is left on the fluorescent screen with the screen properly centered in the beam at a distance of 38 centimeters from the panel or tabletop. Collimators shall provide the same degree of protection as is required in the x-ray tube housing. For image intensifiers, the useful beam shall be centered on the input phosphor within ± 2 percent of the SID and during fluoroscopy or cine-recording it should not exceed the diameter of the input phosphor. Means shall be provided by stepless adjustment to reduce the x-ray field size to 5 by 5 centimeters or less at the maximum SID.

³ Compliance with this part will be determined as follows:

1. The exposure rate due to transmission through the primary barrier combined with radiation through the image intensifier shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.
2. If the source is below the tabletop, the measurement shall be made with the input surface of the fluoroscopic imaging assembly positioned 30 centimeters above the tabletop.
3. If the source is above the tabletop and the SID is variable, the measurement shall be made with the end of the beam-limiting device or spacer as close to the tabletop as it can be placed, provided that it shall not be closer than 30 centimeters.

5. For fluoroscopy, the radiation exposure as measured at the minimum target to skin distance shall be as low as practicable and shall not exceed ~~ten~~ 10 roentgens per minute except where clinically indicated. In cine-radiography, the exposure rates to which patients are normally subjected shall be determined periodically. An adequate period for such measurement shall be annually or after any change in the system that might affect the exposure rate. See ~~1200-02-06-06(2)(d)13.(1)~~ subpart 13(d) of this subparagraph for information on measuring exposure rate.
6. The registrant shall provide protective aprons, and shall require their use by the physician, nurse, technician, and for all other persons within the fluoroscopic room, except the patient.
7. The registrant shall provide protective gloves, and shall require their use by the fluoroscopist during any procedure in which the fluoroscopist may be required to approach the primary beam with his hand or hands.
8. Conventional fluoroscopic screens shall not be used with mobile fluoroscopic equipment. Image intensification shall always be provided, and in the absence of a table top or panel, a cone or spacer frame shall limit the target to skin distance to not less than 30.5 centimeters.
9. X-ray production in the fluoroscopic mode shall be controlled by a device that requires continuous pressure by the fluoroscopist for the entire time of any exposure. When recording serial fluoroscopic images, the fluoroscopist shall be able to terminate the x-ray exposure(s) at any time, but means may be provided to permit completion of any single exposure of the series in process.
10. A cumulative timing device actuated by the exposure switch shall be used that will indicate elapsed exposure time by either interrupting the production of x-rays or by emitting a continuous audible warning signal when the total exposure time exceeds a pre-determined limit not exceeding ~~five~~ 5 minutes in one or a series of exposures.
11. Fluoroscopic table designs when combined with procedures utilized shall be such that no part of any staff or ancillary person's body shall be exposed to unattenuated direct scattered radiation that originates from under the table. The attenuation required shall be at least equivalent to that of 0.25 millimeters of lead.
12. Equipment configuration when combined with procedures shall be such that no portion of any staff or ancillary person's body except the extremities shall be exposed to the unattenuated direct scatter radiation emanating from above the table top unless that individual is at least ~~two~~ 2 meters from the center of the useful beam. This requirement cannot be met only by wearing a protective apron. Exceptions to this requirement may be made in some special procedures. The attenuation required here shall be at least equivalent to that of 0.25 millimeters of lead, (e.g., drapes, folding panel, or self-supporting curtains).
13. Additional requirements applicable to certified systems only.
 - (i) The exposure rate measured at the point where the center of the useful beam enters the patient shall not exceed ~~ten~~ 10 roentgens per minute for equipment incorporating automatic exposure control or ~~five~~ 5 roentgens per minute for equipment not incorporating automatic exposure control except during recording of fluoroscopic images or when provided with optional high level control. When provided with optional high level control, the equipment shall not be operable at any combination of tube potential and current that will result in an exposure rate in excess of ~~five~~ 5 roentgens per minute at the point where the center of the useful beam enters the patient unless the high level control is activated.
 - (l) Special means of activation of high level controls, such as additional pressure applied continuously by the operator, shall be required to

avoid accidental use.

- (II) A continuous signal audible to the fluoroscopist shall indicate that the high level control is being employed.⁴
 - (ii) For image intensified fluoroscopy, neither the length nor the width of the x-ray field in the plane of the image receptor shall exceed the visible area of the image receptor by more than ~~three~~ 3 percent of the SID. The sum of the excess length and the excess width shall be no greater than ~~four~~ 4 percent of the SID. Compliance shall be determined with the beam axis perpendicular to the image receptor. For rectangular x-ray fields used with circular image reception, the error in alignment shall be determined along with the length and width dimensions of the x-ray field that pass through the center of the visible area of the image receptor.
 - (iii) For spot filming, in addition to other requirements of this section:
 - (I) Means shall be provided between the source and the patient for adjustment of the x-ray field size in the plane of the film to the size of that portion of the film that has been selected on the spot-film selector. Such adjustment shall be automatically accomplished except when the x-ray field size in the plane of the film is smaller than that of the selected portion of the film.
 - (II) It shall be possible to adjust the x-ray field size in the plane of the film to a size smaller than the selected portion of the film. The minimum at the greatest SID shall be equal to or less than 5 by 5 centimeters.
 - (III) The center of the x-ray field in the plane of the film shall be aligned with the center of the selected portion of the film to within 2 percent of the SID.
 - (iv) During fluoroscopy and cine-fluorography, x-ray tube potential and current shall be continuously indicated.
- (3) Dental radiographic installations
- (a) Extra-oral dental radiographic equipment shall be considered medical radiographic equipment for the purposes of these regulations.
 - (b) A device shall be used for collimating the primary beam and shall provide the same degree of protection as the tube housing. For intra-oral radiography, the primary beam, as measured at the point where it strikes the patient's face, shall be as small as clinically possible and not more than 7.6 centimeters in diameter. Collimating devices designed to provide rectangular collimation of the primary beam to the size of the dental film should be considered for use when practicable.
 - (c) X-ray apparatus designed for intra-oral radiographic use shall be provided with means to limit the target to skin distance to not less than 18 centimeters if operable above 50 kVp or 10 centimeters if not operable above 50 kVp.

⁴ Compliance with this item shall be determined as follows:

1. For all measurements, the attenuation block with 1/8 inches lead sheet shall be placed in the useful beam between the point of measurement of the entrance exposure rate and the input surface of the fluoroscopic imaging assembly. Bottom surface of the block shall be at least 10 centimeters from the point of measurement of the entrance exposure rate.
2. Movable grids and compression devices shall be removed from the useful beam during the measurement.
3. If the source is below the table, exposure rate shall be measured 1 centimeter above the tabletop or cradle.
4. If the source is above the table, the exposure rate shall be measured at 30 centimeters above the tabletop with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement.
5. In a C-arm type of fluoroscope, the exposure rate shall be measured 30 centimeters from the input surface of the fluoroscopic imaging assembly.

- (d) No one except the patient should be in the room when x-ray exposures are made. If for some reason it is necessary for operating personnel to be in the room with the patient during exposures, an exposure cord shall be provided that is sufficiently long to permit operating personnel to stand at least 2 meters from the patient and the tube head and in an area of minimal exposure to scattered and leakage radiation and outside of the primary beam.
- (e) Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses, or a preset radiation exposure to the image receptor.
1. The exposure shall be reproducible. When ~~four~~ 4 exposures are made at identical technique factors the value of the average exposure (\bar{E}) shall be greater than or equal to 5 times the difference between the maximum exposure (E_{max}) and the minimum exposure (E_{min}), i.e.,

$$\bar{E} \geq 5 (E_{max} - E_{min}).$$
 2. When a timer is provided it:
 - (i) Shall terminate the exposure after a preset time. This preset time shall be only that time necessary for a single exposure.
 - (ii) Shall be reproducible. When ~~four~~ 4 timer tests are performed with a timer setting of 0.5 seconds or less, the average time period (\bar{T}) shall be greater than or equal to 5 times the difference between the maximum period (T_{max}) and the minimum period (T_{min}), i.e.,

$$\bar{T} \geq 5 (T_{max} - T_{min}).$$
- (f) X-ray control (exposure switch)
1. A control shall be incorporated into each x-ray system such that an exposure can be terminated at any time, except for exposures of one-half second or less. A dead-man type control is preferred.
 2. This control shall cause an exposure only if the timer or automatic exposure control has been preset.
 3. During serial radiography, the operator shall be able to terminate the x-ray exposure(s) at any time, but means may be provided to permit completion of any single exposure of the series in progress.
- (g) Neither the tube housing nor the Position Indicating Device may be hand held during an exposure.
- (h) The film shall be held by an appropriate device or by the patient when an x-ray is made, or if necessary, by some other person not occupationally exposed to radiation. The fastest dental film available should be used.
- (i) Fluoroscopic screens shall not be used.
- (j) Filtration
1. Except when contraindicated for a particular diagnostic procedure, the aluminum equivalent of the total filtration (inherent plus added) in the useful beam shall not be less than that shown in Table RHS 3-3.

Table RHS 3-3 FILTRATION REQUIRED VS. OPERATING VOLTAGE

Operating voltage (kVp)	Total filtration (millimeters Al equivalent)
Below 50	0.5
50 - 70	1.5
Above 70	2.5

2. If the thickness of the filter in the x-ray apparatus cannot be determined visually or the total filtration is unknown, it may be assumed that the requirements of (3)(i) part 1 of this Rule subparagraph are met if the half-value is not less than that shown in Table RHS 3-4.

Table RHS 3-4 HALF-VALUE LAYER VS. OPERATING VOLTAGE

Design operating range (kilovolts peak) (kVp)	Measured potential (kVp)	Half-value layer (millimeters of Al equivalent)
Below 50	30	0.3
	40	0.4
	49	0.5
50 to 70	50	1.2
	60	1.3
	70	1.5
	71	2.1
Above 70	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

3. For capacitor energy storage equipment, compliance shall be determined with the maximum quantity of charge per exposure.

- (k) The x-ray tube housing shall be of the diagnostic type.
- (l) The leakage radiation from the diagnostic source assembly measured at a distance of 1 meter in any direction from the source shall not exceed 100 milliroentgens in 1 hour when the x-ray tube is operated at its leakage technique factors. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.
- (m) The radiation emitted by a component other than the diagnostic source assembly shall not exceed 2 milliroentgens in 1 hour at 5 centimeters from any accessible surface of the component when it is operated in an assembled x-ray system under any conditions for which it was designed. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.
- (n) Where two or more tubes are controlled by one exposure switch, the tube or tubes that have been selected shall be clearly indicated prior to initiation of the exposure. This indication shall be both on the x-ray control and at or near the tube housing assembly that has been selected.
- (o) (Reserved)
- (p) Tube housing assemblies shall be equipped with a means to assure mechanical support of the

housing during exposures without drift or vibration.

- (q) In addition to other applicable requirements of this Chapter, diagnostic x-ray equipment certified under the Federal Standards promulgated by the Department of Health and Human Services in the Federal Register shall meet the following requirements:
1. Each registrant shall retain, and shall present to the Division for examination when requested, all information provided by the manufacturer to the purchaser in accordance with the requirements of the applicable Federal standard and shall transfer this information to the subsequent owner of the equipment. See Rule 0400-20-06-09, APPENDIX A, ~~Chapter 1200-02-06~~.
 2. Each registrant shall keep a record of all maintenance and modifications performed on each diagnostic x-ray system containing any components certified under the applicable Federal standard during the period it is under his control, and transfer to the subsequent owner of the equipment.
 3. No deviation from the requirements of these regulations will be considered a violation of these regulations if such deviation is permitted by a variance granted by the Food and Drug Administration, Department of Health and Human Services, or by a regulation promulgated pursuant to Public Law 90-602.
 4. Radiographic systems designed for use with an intra-oral image receptor shall be provided with means to limit the x-ray beam such that:
 - (i) If the minimum source to skin distance (SSD) is 18 centimeters or more, the x-ray field shall be containable in a circle having a diameter of no more than 7 centimeters; and
 - (ii) If the minimum SSD is less than 18 centimeters, the x-ray field at the minimum SSD shall be containable in a circle have a diameter of no more than 6 centimeters.
 5. Notwithstanding ~~(3)~~ subparagraph (j) of this Rule paragraph all dental x-ray systems manufactured on or after December 1, 1980, shall have a minimum half-value layer not less than 1.5 millimeters aluminum equivalent.

Authority: T.C.A. §§ 68-202-101 et seq. and 4-5-201 et seq.

~~1200-02-06-06~~ 0400-20-06-06 Veterinary X-Ray Installations.

(1) General requirements.

(a) Equipment

1. The primary beam for diagnostic purposes in radiography and fluoroscopy shall not be larger than clinically necessary. Cones, diaphragms, or adjustable collimators capable of restricting the primary beam to the area of clinical interest shall be used and shall provide the same degree of protection as is required in the tube housing. See ~~1200-02-06-05 parts (2)(a)1 and 13 and 1200-02-06-06 (2)(c)2 and 7~~ of Rule 0400-20-06-05 for minimum acceptable criteria for cones, diaphragms, or adjustable collimators.
2. Filtration
 - (i) The aluminum equivalent of the total filtration (inherent plus added), permanently in the useful beam shall not be less than that shown in Table RHS 3-1.
 - (ii) If the thickness of the filter in the x-ray apparatus cannot be determined visually or the total filtration is unknown, it may be assumed that the requirements of

(4)(a)2 subpart (i) of this Rule part are met if the half-value layer is not less than that shown in Table RHS 3-2.

3. The x-ray tube housing shall be of diagnostic type.
4. The effectiveness of protective equipment shall not be impaired.
5. A timer shall be provided that will terminate the exposure after a preset time.
6. The exposure switch shall be of a dead-man type.
7. If the operator is required to be in the room during exposures, the registrant shall require the operator to stand at least 2 meters from the animal for all exposures and outside the primary beam.
8. Hand or head held fluoroscopic screens shall not be used.

(b) Operation of equipment

1. Animal or film holding.
 - (i) Except where clinically contraindicated restraining devices or mechanical supporting devices shall be used.
 - (ii) No individual under ~~eighteen~~ 18 years of age and no pregnant women will be used.
 - (iii) No individual shall be used on a consistent or routine basis.
 - (iv) Protective gloves and aprons with at least 0.25 millimeter of lead equivalency shall be provided and their use required of each individual used for this purpose.
 - (v) No part of the body of the individual utilized, for this purpose shall be in the primary beam unless protected by 0.5 millimeter lead equivalent material.
 - (vi) If occupationally exposed persons are utilized their exposure shall be monitored with the monitoring device placed on the collar outside the leaded apron.
 - (vii) A record shall be maintained listing the name of the individual holding the film or animal and shall include the date of the examination and it shall be possible to determine the procedure for which the animal or film was held.

(2) Specific requirements

(a) (Reserved)

(b) Fluoroscopic installations

1. Target to tabletop distance shall not be less than 30.5 centimeters.
2. Equipment installed or reinstalled after July 1, 1972, shall be so constructed that the entire cross-section of the useful beam is attenuated by a primary barrier permanently incorporated into the equipment. The tube mounting and the barrier shall be so linked together that the barrier always intercepts the beam. This barrier is usually the viewing device, either a conventional fluoroscopic screen or an image intensification mechanism.
3. The required lead equivalent of the primary barrier shall be at least 1.5 millimeters for 100 kVp, 1.8 millimeters for 125 kVp, and 2.0 millimeters for 150 kVp.
4. Collimators shall be provided to restrict the size of the useful beam to less than the area

of the primary barrier. For conventional fluoroscopes, this requirement is met if, when the adjustable diaphragm is opened to its fullest extent, an unilluminated margin is left on the fluorescent screen with the screen properly centered in the beam at a distance of 38 centimeters from the panel or tabletop. For image intensifiers, the useful beam shall be centered on the input phosphor and during fluoroscopy or cine-recording it should not exceed the diameter of the input phosphor.

5. For fluoroscopy, the radiation exposure as measured at the minimum target to skin distance shall be as low as practicable and shall not exceed 10 roentgens per minute except when clinically indicated.
6. The registrant shall provide and require the use of a curtain of 0.25 millimeter lead equivalent that will hang from the screen and between the animal and fluoroscopist in both horizontal and vertical fluoroscopy, but it shall not substitute for the wearing of a protective apron.
7. The registrant shall provide protective aprons, and shall require their use by the veterinarian, assistant and for all other persons within the fluoroscopic room.
8. The registrant shall provide protective gloves, and shall require their use by the fluoroscopist during any examination in which the fluoroscopist may be required to approach the primary beam with his hand or hands.
9. Conventional fluoroscopic screens shall not be used with mobile fluoroscopic equipment. Image intensification shall always be provided, and in the absence of a table top or panel, a cone or spacer frame shall limit the target to skin distance to not less than 30.5 centimeters.
10. A shielding device of at least 0.25 millimeter lead equivalent for covering the bucky slot during fluoroscopy shall be provided.

~~4200-02-06-07~~ 0400-20-06-07 Analytical X-Ray Installations.

(1) Equipment.

- (a) The leakage radiation from the tube housing shall not exceed a radiation level of 2.5 milliroentgens in 1 hour at 5 centimeters from the surface of the tube housing at any specified tube rating.
- (b) Radiation originating within the high voltage power supply (i.e., transformer and rectifiers) shall not exceed a radiation level of 0.5 milliroentgen in 1 hour at every specified rating at a distance of 5 centimeters from the housing of the power supply.
- (c) A warning light with the notation "X-Ray On," or equivalent shall be located on the control panel and shall light only when the x-ray tube is activated. This light shall be a fail-safe design or administrative controls shall be exercised to ensure operations will not continue without a proper functioning warning light. On equipment installed after October 2, 1978, this device shall be a fail-safe design.
- (d) The x-ray accessory apparatus shall include a beam trap or other barrier with sufficient shielding so that the dose rate due to the transmitted primary beam does not exceed 0.25 mrem/hr at 5 centimeters under normal operating conditions. The dose rate may be difficult to evaluate in the presence of scattered radiation, however, this requirement shall be considered met if the inherent shielding of the trap or barrier is at least equivalent to the thickness of lead specified in Table RHS 3-5 for the maximum rated anode current and potential.

Table RHS 3-5 THICKNESS OF LEAD REQUIRED FOR A PRIMARY BEAM BARRIER
LOCATED 5 CENTIMETERS FROM THE FOCAL SPOT

Anode

current (mA)	Thickness of lead (mm)		
	50 kVp	70 kVp	100 kVp
20	1.5	5.6	7.7
40	1.6	5.8	7.9
80	1.6	5.9	
100	1.7		

- (e) A light or indicator in a conspicuous location near the tube housing assembly shall be used to indicate when the x-ray tube is on. This light or other indicator shall be of fail-safe design or administrative controls shall be exercised to ensure operations will not continue without proper functioning of this light or indicator. On equipment installed after October 2, 1978, this device shall be of fail-safe design.
- (f) In addition to any signs or labels required in ~~1200-02-05-111~~ Rule 0400-20-05-111, a sign or label shall be placed on or adjacent to each x-ray tube housing and shall be located so as to be clearly visible to any individual who may be working in close proximity to the primary beam path. The sign or label shall bear the words:

"CAUTION - HIGH INTENSITY X-RAY BEAM"

- (g) Where couplings exist, e.g., between the x-ray tube and the collimator of the diffractometer, etc., they shall prevent radiation from escaping the coupling.
- (h) Each port of the radiation source housing shall be provided with a beam shutter interlocked with the x-ray accessory apparatus coupling, or collimator, in such a way that the port will be open only when the collimator or coupling is in place. Shutters at unused ports shall be secured to prevent inadvertent opening.
- (i) Open beam x-ray equipment
1. All shutters shall be provided with a "shutter open" indication of fail-safe design.
 2. Radiation levels in the vicinity of controls and adjustments of the x-ray accessory apparatus used during normal operation shall be such that the operator's exposure shall not exceed in one hour 37 mrem to the hands or 2 mrem to the whole body, gonads, bloodforming organs, or lens of the eye.
 3. A guard or interlock which prevents entry of any part of the body into the primary beam path should be utilized.
 4. The operator shall be in immediate attendance at all times when the equipment is in operation except when the area is locked to protect against unauthorized or accidental entry.
 5. When not in use, equipment shall be secured in such a manner as to be inoperable by unauthorized persons.
- (j) Enclosed beam x-ray equipment
1. The radiation source, sample, detector and analyzing crystal (if used) shall be enclosed in a chamber or coupled chambers that cannot be entered by any part of the body during normal operation.
 2. The sample chamber closure shall be interlocked with the x-ray tube high voltage supply or a shutter in the primary beam so that no x-ray beam can enter the sample chamber while it is open unless the interlock has been conspicuously and deliberately defeated. The interlock required by this section shall be of fail-safe design or adequate

administrative controls shall be exercised to ensure operations will continue without a proper functioning interlock.

3. The exposure level at 5 centimeters from the tube housing apparatus complex shall not exceed 2.5 milliroentgens per hour during normal operation.

(2) Operation of equipment.

- (a) The registrant shall not permit any individual to operate or maintain analytical x-ray equipment until such individual has received instruction in and demonstrated competence as to:
 1. Identification of radiation hazards associated with the use of the equipment;
 2. Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;
 3. Proper operating procedures for the equipment;
 4. Symptoms of an acute localized exposure; and
 5. Proper procedures for reporting an actual or suspected exposure.
- (b) Procedures and apparatus utilized in beam alignment shall be designed to minimize radiation exposure to the operator.
- (c) Written operating procedures and emergency procedures pertaining to radiation safety shall be established for each facility and shall be conspicuously posted in a location near each unit of analytical x-ray equipment.
- (d) Only trained personnel shall be permitted to install, repair, or make modifications to the x-ray generating apparatus and the tube housing apparatus complex.
- (e) Any temporary alteration to safety devices, such as by-passing interlocks or removing shielding shall be:
 1. Approved in advance by the radiation safety officer.
 2. Specified in writing and posted near the x-ray tube housing so that other individuals will know the existing status of the x-ray apparatus.
 3. Terminated as soon as possible.
 4. Recorded and the record maintained for inspection by the Division. This record should contain such information as date alteration was made, type of alteration, length of time unit remained in the altered condition, and signed by the individual who made the alteration and the individual who restored the unit to original condition.
- (f) Tests of all safety devices such as interlocks, shutters, and warning lights shall be conducted at intervals not to exceed 3 months for all operable analytical x-ray equipment. Records of such tests shall be maintained for inspection by the Division.
- (g) Interlocks shall not be used to de-activate the x-ray tube, except in an emergency or during testing of the interlock system. After such shut-off, it shall be possible to restore the machine to full operation only from the control panel.
- (h) Surveys and personnel monitoring shall be provided to insure compliance with the requirements of Chapter ~~4200-02-05~~ 0400-20-05 (See ~~4200-02-05-50~~ Rules 0400-20-05-50, ~~4200-02-05-55~~ 0400-20-05-55, ~~4200-02-05-58~~ 0400-20-05-58, ~~4200-02-05-60~~ 0400-02-05-60, ~~4200-02-05-70~~ 0400-20-05-70, ~~4200-02-05-74~~ 0400-20-05-71(1), ~~4200-02-05-130~~ 0400-20-05-130,

~~1200-02-05-132~~ 0400-20-05-132, and ~~1200-02-05-135~~ 0400-20-05-135.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq. and 4-5-201 et seq.

~~1200-02-06-08~~ 0400-20-06-08 X-Ray Gauges.

(1) Equipment.

- (a) A sign bearing the words, "Warning - X-Rays - Do not place hands in jaws of gauge," or equivalent, shall be so located that it is visible to any person operating, aligning, or adjusting a gauging device.
- (b) A visible indication of the status of the shutter shall be provided, e.g., red light indicating beam on, green light indicating beam off. This device shall be of fail-safe design or administrative controls shall be exercised to ensure operations will not continue without a proper functioning warning device. On equipment installed after June 30, 1977, this device shall be of fail-safe design.
- (c) Except whenever impracticable, an interlocking device which prevents the entry of any portion of an individual's body into the primary beam or causes the primary beam to be shut off upon entry into its path shall be provided.
- (d) Unused tube ports shall be closed in such a fashion that accidental opening is not possible.
- (e) In cases where the primary x-ray beam is not intercepted by the detector device under all conditions of operation, protective measures shall be provided, such as auxiliary shielding, to avoid exposure to any individual from the transmitted primary x-ray beam.

(2) Operation of equipment.

- (a) Personnel working with open beam x-ray equipment shall be provided with finger or wrist personnel monitoring devices. Records of exposure shall be kept as required in ~~1200-02-05-130~~ Rules 0400-20-05-130 and ~~1200-02-05-135~~ 0400-20-05-135.
- (b) When not in operation, the equipment shall be secured in such a way as to be accessible to, or operable by, only authorized personnel.
- (c) A review of all safety devices shall be performed at least quarterly to insure their proper operation (i.e., signs, labels, interlocks, etc.). A record of this review shall be maintained for inspection by the Division.
- (d) Prior to initial startup and subsequent to any change in any parameters affecting radiation safety and at least annually, surveys and monitoring to insure that operations are conducted safely shall be provided. Records of such surveys shall be kept as required by ~~1200-02-05-130~~ Rule 0400-20-05-130 and ~~1200-02-05-132~~ paragraph (1) of Rule 0400-20-05-132.

Authority: T.C.A. §§ 68-202-101 et seq., 68-202-201 et seq. and 4-5-201 et seq.

~~1200-02-06-09~~ 0400-20-06-09 Appendix A.

Excerpt from Bureau of Radiological Health Standards for Certified Diagnostic X-ray Equipment. See subpart (2)(a)14(i) and part (3)(q)1 of Rule ~~1200-02-06-05(2)(a)14(i)~~ and ~~1200-02-06-05(3)(q)1~~ 0400-20-06-05.

- (1) Manufacturers of x-ray equipment shall provide for purchaser and, upon request, to others at a cost not to exceed the cost of publication and distribution, manuals or instruction sheets which shall include the following technical and safety information:

- (a) All x-ray equipment.

For x-ray equipment to which this section Chapter and 21 CFR 1020.31 and 1020.32 are

applicable, there shall be provided:

1. Adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the equipment; and
2. A schedule of the maintenance necessary to keep the equipment in compliance with this ~~section~~ Chapter and 21 CFR 1020.31 and 1020.32.

(b) Tube housing assemblies.

For each tube housing assembly, there shall be provided:

1. Statements of the maximum rated peak tube potential, leakage technique factors, the minimum filtration permanently in the useful beam expressed as millimeters of aluminum equivalent, and the peak tube potential at which the aluminum equivalent was obtained;
2. Cooling curves for the anode and tube housing; and
3. Tube rating charts.

If the tube is designed to operate from different types of x-ray high voltage generators (such as single-phase self-rectified, single phase half-wave rectified, single-phase full-wave rectified, three-phase ~~6~~ pulse, three-phase 12 pulse, constant potential, capacitor energy storage) or under modes of operation such as alternate focal spot sizes or speeds of anode rotation which affect its rating, specific identification of the difference in ratings shall be noted.

(c) X-Ray controls and generators.

For the x-ray control and associated x-ray high-voltage generator, there shall be provided:

1. A statement of the rated line voltage and the range of line-voltage regulation for operation at maximum line current;
2. A statement of the maximum line current of the x-ray system based on the maximum input voltage and current characteristics of the tube housing assembly compatible with rated output voltage and rated output current characteristics, x-ray control and associated high-voltage generator. If the rated input voltage and current characteristics of the tube housing assembly are not known by the manufacturer of the x-ray control and associated high-voltage generator, he shall provide necessary information to allow the purchaser to determine the maximum line current for his particular tube housing assembly(s);
3. A statement of the technique factors that constitute the maximum line current condition described in ~~subdivision (ii)~~ part 2 of this subparagraph;
4. In the case of battery-powered generators, a specification of the minimum state of charge necessary for operation.
5. Generator rating and duty cycle;
6. A statement of the maximum deviation from the indication given by labeled control settings and/or meters during any exposure when the equipment is connected to a power supply as described in accordance with this paragraph. In the case of fixed technique factors, the maximum deviation from the nominal fixed value of each factor shall be stated; and
7. A statement defining the measurement basis (or bases) upon which the exposure time, peak potential, tube current, and/or other technique factors are stated pursuant to ~~subdivisions (iii) and (vi)~~ parts 3 and 6 of this subparagraph.

(d) Variable-aperture beam-limiting device.

For each variable-aperture beam limiting device, there shall ~~e~~ be provided:

1. Specifications of tube housing assemblies for which the device is designed or is compatible with respect to the requirements of ~~paragraph (k) of this section~~ Chapter and 21 CFR 1020.31 (d) and (e); and
2. A statement including the minimum aluminum equivalent of that part of the device through which the useful beam passes and including the x-ray tube potential at which the aluminum equivalent was obtained. When ~~two~~ 2 or more filters are provided as part of the device, the statement shall include the aluminum equivalent of each filter.

Authority: T.C.A. §§ 68-202-101 et seq. and 4-5-201 et seq.